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AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1928

(INCORPORATED 1881.)

VOL. LXII.

EDITED BY

THE HONORARY SECRETARIES.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

SYDNEY:
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VOLUME LXII.

NOTICE.

The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors should submit their papers in typescript and in a condition ready for printing. All physico-chemical symbols and mathematical formulæ should be so clearly written that the compositor should find no difficulty in reading the manuscript. Sectional headings and tabular matter should not be underlined. Pen-illustrations accompanying papers should be made with black Indian ink upon smooth white Bristol board. Lettering and numbers should be such that, when the illustration or graph is reduced to $3\frac{1}{2}$ inches in width, the lettering will be quite legible. On graphs and text figures any lettering may be lightly inserted in pencil. Microphotographs should be rectangular rather than circular, to obviate too great a reduction. The size of a full page plate in the Journal is $4 \times 6\frac{1}{4}$ inches, and the general reduction of illustrations to this limit should be considered by authors. When drawings, etc., are submitted in a state unsuitable for reproduction, the cost of the preparation of such drawings for the process-block maker must be borne by the author. The cost of colouring plates or maps must also be borne by the author.

FORM OF BEQUEST.

I bequeath the sum of £ to the Royal Society of New South Wales, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

PUBLICATIONS.

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The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.
Vols. I—XI Transactions of the Royal Society, N.S.W., 1867—1877, ,,

,,	XII	Journal and Proceedings	,,	,,	1878,	,,	324,	price 10s.6d.
,,	XIII	,, ,, ,,	,,	,,	1879,	,,	255,	,,
,,	XIV	,, ,, ,,	,,	,,	1880,	,,	391,	,,
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,,	LV	,, ,, ,,	,,	,,	1921,	,,	418,	,,
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Royal Society of New South Wales.

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Rev. E. F. PIGOT, S.J., B.A., M.B.

*Deceased 28th November, 1928

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Journal. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1908		Abbott, George Henry, B.A., M.B., Ch.M., 185 Macquarie-street; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1904		Adams, William John, M.I.Mech.E., 175 Clarence-street.
1898		Alexander, Frank Lee, William-street, Granville.
1905	P 3	Anderson, Charles, M.A., D.Sc. *Edin.*, Director of the Australian Museum, College-street. (President, 1924.) *Vice-President.*
1909	P 9	Andrews, Ernest C., B.A., F.G.S., Hon. Mem. Washington Academy of Sciences, Government Geologist, Department of Mines, Sydney. (President, 1921.)
1915		Armit, Henry William, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, The Printing House, Seamer-street. Glebe.
1919		Aurousseau, Marcel, B.Sc., c/o Post Office, Manly.
1923		Baccarini, Antonio, Doctor in Chemistry (Florence).
1878		Backhouse, His Honour Judge A. P., M.A., 'Melita,' Elizabeth Bay.
1924		Bailey, Victor Albert, M.A., D.Phil., F.Inst.P., Assoc.-Professor of Physics in the University of Sydney.
1919		Baker, Henry Herbert, 15 Castlereagh-street.
1894	P 27	Baker, Richard Thomas, The Crescent. Cheltenham.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1926		Bannon, Joseph, Demonstrator in Physics in the University of Sydney; p.r. 'Dunisla,' The Crescent, Homebush.
1919		Bardsley, John Ralph, 'The Pines,' Lea Avenue, Five Dock.
1925		Barker-Woden, Lucien, F.R.G.S., Commonwealth Department of Navigation, William Street, Melbourne.
1908	P 1	Barling, John, L.S., 'St. Adrians,' Raglan-street, Mosman.
1895	P 9	Barraclough, Sir Henry, K.B.E., B.E., M.M.E., M. Inst. C.E., M. I. Mech. E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Dean of the Faculty of Engineering and Professor of Mechanical Engineering in the University of Sydney; p.r. 'Marmion,' Victoria-street, Lewisham.
1909	P 2	Benson, William Noel, D.Sc. *Syd.*, B.A. *Cantab.*, F.G.S., Professor of Geology in the University of Otago, Dunedin, N.Z.
1926		Bentivoglio, Sydney Ernest, B.Sc.Agr., 70 Young-street, Annandale.
1923		Berry, Frederick John, F.C.S., 'Roseneath,' 51 Reynolds-street, Neutral Bay.
1919		Bettley-Cooke, Hubert Vernon, 'The Hollies,' Minter-street, Canterbury.
1923		Birks, George Frederick, c/o Potter & Birks, 15 Grosvenor-st.

Elected.		
1916		Birrell, Septimus, c/o Margarine Co., Edinburgh Road, Marrickville.
1920		Bishop, Eldred George, 8 Belmont-road, Mosman.
1915		Bishop, John, 24 Bond-street.
1913		Bishop, Joseph Eldrod, Killarney-street, Mosman.
1923	P 4	Blakely, William Faris, 'Myola,' Florence-street, Hornsby.
1905		Blakemore, George Henry, 68½ Pitt Street, Sydney.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 'Inglewood,' Florida Road, Palm Beach, Sydney.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1917		Bond, Robert Henry, 'Eastbourne,' 27 Cremorne-road, Cremorne Point.
1926	P 1	Booker, Frederick William, B.Sc., 'Dunkeld,' Nicholson-street, Chatswood.
1920	P 4	Booth, Edgar Harold, M.C., B.Sc., F Inst.P., Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Bradfield, John Job Crew, D.Sc. Eng., M.E., M. Inst. C.E., M. Inst. E. Aust. Chief Engineer, Metropolitan Railway Construction, Railway Department, Sydney.
1916		Bragg, James Wood, B.A., c/o Gibson, Battle &Co. Ltd.,Kent-st.
1926		Branch, Kenneth James F., 99 North Steyne, Manly.
1917		Breakwell, Ernest, B.A., B.Sc, Headmaster Agricultural School, Yanco.
1891		Brennand, Henry J. W., B.A., M.D., Ch.M. *Syd.*, V.D., Surgeon Commander R.A.N. Ret., 223 Macquarie-street; p.r. 73 Milsons Road, Cremorne.
1923		Brereton, Ernest Le Gay, B Sc., Lecturer and Demonstrator in Chemistry in the University of Sydney.
1919	P 1	Briggs, George Henry, B.Sc., Ph.D., Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Brough, Patrick, M.A., B.Sc., B.Sc., (Agr) (Glasgow), Lecturer in Botany in the University of Sydney.
1923		Brown, Herbert, 'Sikoti,' Alexander-street, Collaroy Beach, Sydney.
1906		Brown, James B., St. Andrew's, Mont Victor Road, East Kew, E. 4, Victoria.
1913	P 15	Browne, William Rowan, D.Sc., Assistant-Professor of Geology in the University of Sydney.
1898		‡Burfitt, W. Fitzmaurice, B.A., M.B., Ch.M. B.Sc., *Syd.*, 'Wyoming,' 175 Macquarie-street, Sydney.
1926		Burkitt, Arthur Neville St. George, M.B , B.Sc., Professor of Anatomy in the University of Sydney.
1919	P 10	Burrows, George Joseph, B.Sc., Lecturer and Demonstrator in Chemistry in the University of Sydney; p.r. Watson-street, Neutral Bay.
1909		Calvert, Thomas Copley, Assoc.M.Inst.C.E , Department of Public Works, Sydney.
1928		Cameron, Lindsay Duncan, Hilly-street, Mortlake.
1907		Campbell, Alfred W., M.D., Ch.M. *Edin.*, 183 Macquarie-street.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.* F.F.A., *Scot.*, 4 Whaling Road, North Sydney.
1920		Carruthers, Sir Joseph Hector, K.C.M.G., M.L.C., M.A., *Syd.*, LL.D., *St. Andrews*, 'Highbury,' Waverley.

Elected		
1903	P 3	Carslaw, Horatio S., M.A., Sc. D., Professor of Mathematics in the University of Sydney.
1913	P 3	Challinor, Richard Westman, F.I.C., F.C.S., Lecturer in Chemistry, Sydney Technical College.
1909	P 2	Chapman, Henry G., M.D., B.S., Director of Cancer Research, University of Sydney. *Hon. Treasurer.*
1913	P 16	Cheel, Edwin, Curator National Herbarium, Botanic Gardens, Sydney.
1925	P 1	Clark, William E., 'Acacia,' Cambridge-street, Epping.
1909	P 20	Cleland, John Burton, M.D., Ch.M., Professor of Pathology in the University of Adelaide. (President 1917.)
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.* and *Edin.*, 'Roseneath,' 8 Wallis-street, Woollahra.
1896	P 4	Cook, W. E., M.C.E. *Melb.*, M.Inst.,C.E., Burroway-st., Neutral Bay.
1920		Cooke, Frederick, c/o Meggitt's Limited, 26 King-street.
1913	P 3	Coombs, F. A., F.C.S., Instructor of Leather Dressing and Tanning, Sydney Technical College; p.r. Bannerman Crescent, Rosebery.
1928		Coppleson, Victor Marcus, M.B., Ch.M., F.R.C.S., 225 Macquarie-street, Sydney.
1882		Cornwell, Samuel, J.P., 'Capanesk,' Tyagarah, North Coast.
1919		Cotton, Frank Stanley, B.Sc., Chief Lecturer and Demonstrator in Physiology in the University of Sydney.
1909	P 6	Cotton, Leo Arthur, M.A., D.Sc., Professor of Geology in the University of Sydney.
1892	P 1	Cowdery, George R., Assoc.M.Inst.C.E., 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 185 Macquarie-st.
1921		‡Cresswick, John Arthur, 101 Villiers-street, Rockdale.
1927	P 1	Currey, Geoffrey Saunders, 13 Princess-avenue, Homebush.
1925		Curry, Harris Eric Marshall, c/o M. Barker, Esq., Kincumber, N.S.W.
1912		Curtis, Louis Albert, L.S., F.I.S. (N.S.W.), V.D., Room 618, New Government Savings Bank, Castlereagh-street; p.r. No. 1 Mayfair Flats, Macleay-street, Darlinghurst.
1886	P 23	David, Sir Edgeworth, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., Wollaston Medallist, Emeritus Professor of Geology and Physical Geography in the University of Sydney; p.r. 'Coringah,' Sherbroke-road, Hornsby. (President 1895, 1910.)
1928		Davidson, Walter Charles, General Manager Clyde Engineering Company, Granville.
1890		Dare, Henry Harvey, M.E., M.Inst.C.E., Commissioner, Water Conservation and Irrigation Commission, Union House, George-street.
1919	P 2	de Beuzeville, Wilfrid Alex. Watt, Forestry Assessor, Forest Office, Tumut.
1921		Delprat, Guillaume Daniel, C.B.E., 'Keynsham,' Mandeville Crescent, Toorak, Victoria.
1921		Denison, Sir Hugh Robert, K.B.E., 701 Culwulla Chambers, Castlereagh-street.
1894		Dick, James Adam, C.M.G., B.A. *Syd.*, M.D., Ch.M., F.R.C.S. *Edin.*, 'Catfoss,' 59 Belmore Road, Randwick.

Elected		
1906		Dixson, William, 'Merridong,' Gordon Road, Killara.
1913	P 3	Doherty, William M., F.I.C., F.C.S., Second Government Analyst, 'Jesmond,' George-street, Marrickville.
1928		Donegan, Henry Arthur James, A.S.T.C., Chemical Laboratory, Department of Mines, Sydney.
1908	P 6	Dun, William S., Palæontologist, Department of Mines, Sydney. (President 1918.)
1924		Dupain, George Zephirin, A.A.C.I., F.C.S., Dupain Institute of Physical Education, Manning Building, Pitt and Hay Streets, Sydney, p.r. 'Symington,' Parramatta Road, Ashfield.
1924		Durham, Joseph, 120 Belmore Road, Randwick.
1923	P 2	Earl, John Campbell, D.Sc. Ph.D., Professor of Organic Chemistry in the University of Sydney.
1919		Earp, The Hon. George Frederick, C.B.E., M.L.C., Australia House, Carrington-street.
1924		Eastaugh, Frederick Alldis, A.R.S.M., F.I.C., Assoc. Professor in Chemistry, Assaying and Metallurgy in the University of Sydney.
1918		‡Elliott, Edward, c/o Reckitts' (Oversea) Ltd., Bourke-street, Redfern.
1916	P 2	Enright, Walter J., B.A., High-street, West Maitland, N.S.W.
1908		Esdaile, Edward William, 42 Hunter-street.
1896		Fairfax, Geoffrey E., Hon. LL.D. (Toronto), B.A., *S. M. Herald* Office, Hunter-street.
1887		Faithfull, R. L., M.D., *New York*, L.R.C.P., L.S.A. *Lond.*, c/o Iceton, Faithfull and Maddocks, 25 O'Connell-street.
1921		Farnsworth, Henry Gordon, 'Rothsay,' 90 Alt-street, Ashfield.
1910		Farrell, John, A.T.C., *Syd.*, Riverina Flats, 265 Palmer-street, Sydney.
1909	P 7	Fawsitt, Charles Edward, D.Sc., Ph.D., Professor of Chemistry in the University of Sydney. (President 1919).
1922		Ferguson, Andrew, 9 Martin Place, Sydney.
1927	P 1	Finnemore, Horace, B.Sc., F.I.C., Lecturer in Pharmacy in the University of Sydney.
1923		Fiaschi, Piero, O.B.E., M.D. (Columbia Univ.), D.D.S. (New York) M.R.C.S. (Eng.), L.R.C.P. (Lond.), 178 Phillip-street.
1920		Fisk, Ernest Thomas, Wireless House, 47 York-street.
1888		Fitzhardinge, His Honour Judge G. H., M.A. 'Red Hill,' Pennant Hills.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.* L.R.C.P. *Edin.*, 'The Astor,' Macquarie-street.
1920		Fortescue, Albert John, 'Benambra,' Loftus-street, Arncliffe.
1905		Foy, Mark, c/o Hydro Office, 133a Pitt-street, Sydney.
1904		Fraser, James, C.M.G., M.Inst.C.E., Chief Commissioner for Railways, Bridge-street.
1925		Friend, Norman Bartlett, 48 Pile-street, Dulwich Hill.
1918		Gallagher, James Laurence, M.A. *Syd.*, 'Akaroa,' Ellesmere Avenue, Hunter's Hill.

Elected		
1926		Gibson, Alexander James, M.E., M.Inst.C.E., M.I E.Aust., 906 Culwulla Chambers, Castlereagh-street, Sydney.
1921		Godfrey, Gordon Hay, M.A., B.Sc., Lecturer in Physics in the Technical College, Sydney; p.r. 262 Johnston-street, Annandale.
1897		Gould, The Hon. Sir Albert John, K.B., V.D., 'Eynesbury,' Edgecliff.
1922	P 5	Grant, Robert, F.C.S., Department of Public Health, 93 Macquarie-street.
1916		Green, Victor Herbert, 19 Bligh-street.
1922	P 2	Greig, William Arthur, Mines Department, Sydney.
1927		Gunn, Reginald Montague Cairns, B.Sc., B.Sc.Agr., M.R.C.V.S. Lecturer in Veterinary Anatomy and Surgery in the University of Sydney.
1923		Gurney, William Butler, Government Entomologist, Department of Agriculture, Sydney.
1919		
1880	P 5	Halligan, Gerald H., L.S., F.G.S., "Uplands," Station Street, Pymble.
1912		Hallmann, E. F., B.Sc., 72 John-street, Petersham.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1919		Hambridge, Frank, Adelaide Steamship Co. Chambers, Bridge-street, Sydney.
1916	P 1	Hamilton, Arthur Andrew, 'The Ferns,' 17 Thomas-st., Ashfield
1912		Hamilton, Alexander G., 'Tanandra,' Hercules-st., Chatswood.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; 'Glendowan,' Glenbrook, Blue Mountains. B.M.A. Building, 30 Elizabeth-st. (President 1899, 1908).
1909		Hammond, Walter L., B.Sc., High School, Bathurst.
1916		Hardy, Victor Lawson, 'Tiri Mona,' 11A Gordon-av., Randwick
1905	P 5	Harker, George, D.Sc., F.A.C.I., Chamber of Commerce Building, 35 William-street, Melbourne.
1913	P 1	Harper, Leslie F., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1923	P 1	Harrison, Travis Henry, Lecturer in Entomology and Botany at the Hawkesbury Agricultural College, Richmond.
1918		Hassan, Alex. Richard Roby, c/o W. Angliss & Co. Ppty. Ltd., 64 West Smithfield, London, E.C.
1916		Hay Dalrymple-, Richard T., L.S.; 45 Bay-street, Double Bay
1914		Hector, Alex. Burnet, "Druminard," Greenwich-road, Greenwich.
1916		Henderson, James, 'Dunsfold,' Clanalpine-street, Mosman.
1919		Henriques, Frederick Lester, 208 Clarence-street.
1919	P 2	Henry, Max, D.S.O., B.V.Sc., M.R.C.V.S., 'Coram Cottage,' Essex-street, Epping.
1884	P 1	Henson, Joshua B., Assoc.M.Inst.C.E., 28 Barton-street, Mayfield, Newcastle.
1918		Hindmarsh, Percival, M.A., B.Sc. (Agr.), Teachers' College, The University, Sydney; p.r. 'Lurnea,' Canberra Avenue, Greenwich.
1921	P 2	Hindmarsh, William Lloyd, B.V.Sc, M.R.C.V.S., D.V.H., District Veterinary Officer, Glenfield.
1928		Hirst, George Walter Cansdell, B.Sc., Chief Mechanical Engineer's Office, Wilson Street, Redfern.

Elected.		
1916		Hoggan, Henry James, A.M.I.M.E., A.M.I.E. (Aust.). Manchester Unity Chambers, 160 Castlereagh-street; p r. 'Lincluden,' Frederick-street, Rockdale.
1924		Holme, Ernest Rudolph, O.B.E., M.A., Professor of English Language in the University of Sydney.
1901		Holt, Thomas S., 'Amalfi,' Appian Way, Burwood.
1905	P 3	Hooper, George, J.P., F.T.C. *Syd.*, 'Mycumbene,' Nielsen Park, Vaucluse.
1920		Hordern, Anthony, C.B.E., 12 Spring-street, Sydney.
1919		Hoskins, Arthur Sidney, Eskroy Park, Bowenfels.
1919		Hoskins, Cecil Harold, Windarra, Bowenfels.
1919		Houston, Ralph Liddle, No. 1 Lincluden Gardens, Fairfax-rd., Double Bay.
1913		Hudson, G. Inglis, J.P., F.C.S., 'Gudvangen,' Arden-st., Coogee.
1920		Hulle, Edward William, Commonwealth Bank of Australia.
1923	P 2	Hynes, Harold John, B.Sc., (Agr.), Walter and Eliza Hall Agricultural Research Fellow, Biological Branch, Department of Agriculture, Sydney.
1927		Inglis, William Keith, M.D., Ch.M., Lecturer in Pathology in the University of Sydney; p.r. 34 Wolseley-street, Drummoyne.
1923		Ingram, William Wilson, M.C., M.D., Ch.B., 185 Macquarie-st., Sydney.
1922		Jacobs, Ernest Godfried, 'Cambria,' 106 Bland-street, Ashfield.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Chief Inspector of Mines, Department of Mines, Sydney.
1925		Jenkins, Charles Adrian, B.E., B.Sc., 2 Ramsgate Avenue, Bondi Beach.
1917		Jenkins, Richard Ford, Engineer for Boring, Irrigation Commission, 6 Union-street, Mosman.
1918		John, Morgan Jones, M.I.Mech.E., A.M.I.E.E. *Lond.*, M.I.E. *Aust.*, M.I.M. *Aust.*, Atlas Building, 8 Spring-street; p.r. Olphert Avenue, Vaucluse.
1909	P 15	Johnston, Thomas Harvey, M.A., D.Sc., F.L.S., C.M.Z.S., Professor of Zoology in the University of Adelaide.
1924		Jones, Leo Joseph, Geological Surveyor, Department of Mines, Sydney.
1911		Julius, George A., Sir, Kt., B.Sc., M.E., M.I.Mech.E., Culwulla Chambers, Castlereagh-street, Sydney.
1924		Kenner, James, Ph. D., D.Sc., F.R.S., Professor of Technological Chemistry in the University of Manchester.
1924		Kenny, Edward Joseph, Field Assistant, Department of Mines, Sydney; p.r. 45 Robert-street, Marrickville.
1887		Kent, Harry C., M.A., F.R.I.B.A., Dibbs' Chambers, 58 Pitt-st.
1919	P 3	Kesteven, Hereward Leighton, M.D., Ch.M., D.Sc., Bulladelah, New South Wales.
1896		King, Kelso, 14 Martin Place.

Elected

1923 Kinghorn, James Roy, Australian Museum, Sydney.

1920 Kirchner, William John, B.Sc., "Wanawong," Thornleigh-road, Beecroft.

1919 Kirk, Robert Newby, 25 O'Connell-street

1877 Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.

1924 Leech, Thomas David James, B.Sc., *Syd.*, 'Orontes,' Clarke-st., Granville.

1920 Le Souef, Albert Sherbourne, Taronga Park, Mosman.

1916 L'Estrange, Walter William, 7 Church-street, Ashfield.

1909 Leverrier, Frank, B.A., B.Sc., K.C., Wentworth Road, Vaucluse.

1883 Lingen, J. T., M.A. *Cantab.*, K.C., c/o Union Club, Bligh-st.

1906 Loney, Charles Augustus Luxton, M.Am.Soc.Refr.E., Equitable Building, George-street.

1924 Love, David Horace, Beauchamp Avenue, Chatswood.

1927 Love, William Henry, B.Sc., "Lumeah," 9 Miller-street, Haberfield.

1884 MacCormick, Sir Alexander, K.C.M.G., M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street.

1923 Mackay, Iven Giffard, C.M.G., D.S.O., B.A., Student Adviser and Secretary of Appointments Board, The University, Sydney.

1921 McDonald, Alexander Hugh Earle, Superintendent of Agriculture, Department of Agriculture, Sydney.

1903 McDonald, Robert, J.P., L.S., Pastoral Chambers, O'Connell-st; p.r. 'Lowlands,' William-street, Double Bay.

1919 McGeachie, Duncan, M.I.M.E., M.I.E. (Aust.), M.I.M.M. (Aust.), 'Craig Royston,' Toronto, Lake Macquarie.

1906 McIntosh, Arthur Marshall, 'Moy Lodge,' Hill-st., Roseville.

1891 P 2 McKay, R. T., L.S., M.Inst.C.E., Commissioner, Sydney Harbour Trust, Circular Quay.

1880 P 9 McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M.Inst.C.E., Sydney Safe Deposit, Paling's Buildings, Ash-street.

1922 McLuckie, John, M.A., B.Sc., (*Glasgow*), D.Sc. (*Syd.*), Assistant-Professor of Botany in the University of Sydney.

1927 McMaster, Frederick Duncan, "Dalkeith," Cassilis.

1916 McQuiggin, Harold G., M.B., Ch.M., B.Sc., Lecturer and Demonstrator in Physiology in the University of Sydney; p.r. 'Berolyn,' Beaufort-street, Croydon.

1909 Madsen, John Percival Vissing, D.Sc., B.E., Professor of Electrical Engineering in the University of Sydney.

1924 Mance, Frederick Stapleton, Under Secretary for Mines, Mines Department, Sydney; p.r. 'Binbah,' Lucretia Avenue, Longueville.

1880 P 1 Manfred, Edmund C., Montague-street, Goulburn.

Elected.		
1920	P 1	Mann, Cecil William.
1920		Mann, James Elliott Furneaux, Barrister at Law, c/o H. Southerden, Esq., Box 1646 J.J., G.P.O., Sydney.
1908		Marshall, Frank, C.M.G., B.D.S., 151 Macquarie-street.
1914		Martin, A. H., Technical College, Sydney.
1926		Mathews, Hamilton Bartlett, B.A. *Syd.*, Surveyor General of N.S.W., Department of Lands, Sydney.
1912		Meldrum, Henry John, B.A., B.Sc. 'Craig Roy,' Sydney Road, Manly.
1922		Mills, Arthur Edward, M.B., Ch.M., Dean of the Faculty of Medicine, Professor of Medicine in the University of Sydney; p.r. 143 Macquarie-street.
1928		Mitchell, Louis Ivan, Ph.D., Colonial Sugar Refining Co., Pyrmont.
1926		Mitchell, Ernest Marklow, 106 Harrow Road, Rockdale
1879		Moore, Frederick H., Union Club, Sydney.
1922	P 13	Morrison, Frank Richard, A.A.C.I., F.C.S., Assistant Chemist, Technological Museum, Sydney; p.r. Brae-st., Waverley.
1924		Morrison, Malcolm, Department of Mines, Sydney.
1924		Mullens, Arthur Launcelot, 65 Woodside Avenue, Strathfield.
1879		Mullins, John Lane, M.L.C., M.A. *Syd.*, 'Killountan,' Double Bay.
1915		Murphy, R. K., Dr. Ing., Chem. Eng., Lecturer in Chemistry Technical College, Sydney.
1923	P 2	Murray, Jack Keith, B.A., B.Sc. (Agr.), Principal, Queensland Agricultural College, Gatton, Queensland.
1893	P 4	Nangle, James, O.B.E., F.R.A.S., Superintendent of Technical Education, The Technical College, Sydney; Government Astronomer, The Observatory, Sydney. (President 1920., *Vice-President*.
1917		Nash, Norman C., 'Ruanora,' King's Road, Vaucluse.
1924		Nickoll, Harvey, L.R.C.P., L.R.C.S., Barham, via Mudgee, N.S.W.
1891		‡Noble, Edward George, L.S., 8 Louisa Road, Balmain.
1920	P 2	Noble, Robert Jackson, M.Sc., B.Sc.Agr., Ph.D., Agricultural Museum, George-street, North; p.r. 'Lyndon,' Carrington-street, Homebush.
1903		‡Old, Richard, 'Waverton,' Bay Road, North Sydney.
1921		Olding, George Henry, "Worriwee," Wright's Road, Drummoyne.
1913		Ollé, A. D., F.C.S., 'Kareema,' Charlotte-street, Ashfield.
1917		Ormsby, Irwin, 'Caleula,' Allison Road, Randwick.
1891		Osborn, A. F., Assoc.M.Inst.C.E., Water Supply Branch, Sydney; p.r. 'Waugoola,' Fern-street. Pymble.
1928		Osborn, Theodore George Bentley, D.Sc., F.L.S., Professor of Botany in the University of Sydney.
1921	P 2	Osborne, George Davenport, D.Sc., Lecturer and Demonstrator in Geology in the University of Sydney; p.r. 'Belle-Vue,' Kembla-st., Arncliffe.

Elected		
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1921		Parkes, Varney, Conjola, South Coast.
1928		Parsons, Stanley William Enos, Analyst and Inspector, N.S.W. Explosive Department, p.r. Shepherd Road, Artarmon.
1920	P 49	Penfold, Arthur Ramon, F.C.S., Curator and Economic Chemist, Technological Museum, Harris-street, Ultimo.
1909	P 2	Pigot, Rev. Edward F., S.J., B.A., M.B. *Dub.*, Director of the Seismological Observatory, St. Ignatius' College, Riverview.
1879	P 8	Pittman, Edward F., Assoc.R.S.M.. L.S., 'The Oaks,' Park-street, South Yarra, Melbourne.
1881		Poate, Frederick, F.R.A.S., L.S., 'Clanfield,' 50 Penkivil-street, Bondi.
1919		Poate, Hugh Raymond Guy, M.B., Ch. M. *Syd.*, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 225 Macquarie-street.
1917		Poole, William, M.E., (Civil, Min. and Met.) *Syd.*, M. Inst. C.E., M.I.M.M., M.I.E., Aust., M.Am. I.M.E., M. Aust. I. M.M., L.S., 906 Culwulla Chambers, Castlereagh-street. *President.* (Member from 1891 to 1904.)
1896		Pope, Roland James, B.A., *Syd.*, M.D., Ch.M., F.R.C.S.. *Edin.*, 185 Macquarie-street.
1921	P 2	Powell, Charles Wilfrid Roberts, A.I.C., c/o Colonial Sugar Refining Co., O'Connell-street.
1918		Powell, John, 17 Thurlow-street, Redfern.
1927		Price, William Lindsay, B.E., B.Sc., "Malola," Smith-road, Artarmon.
1918		Priestley, Henry, M.D., Ch. M., B.Sc., Associate-Professor of Physiology in the University of Sydney.
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 185 Macquarie-street.
1927		Radcliffe-Brown, Alfred Reginald, M.A., *Cantab.*, M.A., *Adel.*, F.R.A.I., *Cantab.*, Professor of Anthropology in the University of Sydney.
1922		Raggatt, Harold George, B.Sc., "Meru," Epping-av., Epping.
1919	P 3	Ranclaud, Archibald Boscawen Boyd, B.Sc., B.E., Lecturer in Physics, Teachers' College, The University, Sydney.
1909		Reid, David, 'Holmsdale,' Pymble.
1928		Reidy, Eugene Nicholas, A.S.T.C., Analyst, Department of Mines, Sydney.
1920		Richardson, John James, A.M.I.E.E. *Lond.*, 'Kurrawyba,' Upper Spit Road, Mosman.
1924		Robertson, James R. M.. M.D., C.M., F.R.G.S., F.G.S., 'Vanduara,' Ellamang Avenue, Kirribilli.
1928		Ross, Allan Clunies, B.Sc., 15 Castlereagh-street, Sydney. (Member from 1915 to 1924.)
1884	P 1	Ross, Chisholm, M.D. *Syd.*, M.B., Ch.M., *Edin.*, 225 Macquarie-st.
1895		Ross, Herbert E., Equitable Building, George-street.
1927		Ross, Ian Clunies, D.V.Sc., "Lorne," The Grove, Woollahra.
1925		Roughley, Theodore Cleveland, Technological Museum, Sydney.
1907		Ryder, Charles Dudley, *D. Eng.* (Vienna), Assoc.I.R.S.M., (L.), Ass.A.C.I., F.C.S., (L.), Public Analyst (by appoint.), 59 Patterson-street; Concord.

Elected		
1922		Sandy, Harold Arthur Montague, 326 George-street.
1926		Saunderson, William, B.Sc. *Dun.*, F.C.S., Licentiate, College of Preceptors *England*, c/o Imperial Service Club, 12 O'Connell-street, Sydney.
1920		Sawyer, Basil, B.E., 'Birri Birra,' The Crescent, Vaucluse.
1920		Scammell, Rupert Boswood, B.Sc. *Syd.*, 18 Middle Head Road, Mosman.
1919		Sear, Walter George Lane, c/o J. Kitchen & Sons, Ingles-st., Port Melbourne.
1923	P 1	Seddon, Herbert Robert, D.V.Sc., Director, Veterinary Research Station, Glenfield.
1918		Sevier, Harry Brown, c/o Lewis Berger and Sons (Aust.) Ltd., Cathcart House, Castlereagh-street.
1924		Shelton, James Peel, M.Sc., B.Sc., Agr., Department of Agriculture, Canberra.
1927		Shearsby, Alfred James, 152 Bland-street, Haberfield.
1917		Sibley, Samuel Edward, Mount-street, Coogee.
1900		‡Simpson, R. C., Lecturer in Electrical Engineering, Technical College, Sydney.
1922	P 1	Smith, Thomas Hodge, Australian Museum, Sydney.
1919		Southee, Ethelbert Ambrook, O.B.E., M.A., B.Sc., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1921		Spencer-Watts, Arthur, 'Araboonoo,' Glebe-street, Randwick.
1917		Spruson, Wilfred Joseph, Daily Telegraph Building, King-st.
1916		Stephen, Alfred Ernest, F.C.S., Box 1197 H.H.G.P.O., Sydney.
1921		Stephen, Henry Montague, B.A., LL.B., c/o Messrs. Maxwell and Boyd, 17 O'Connell-street.
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., Captain Piper's Road and New South Head Road, Vaucluse.
1920	P 1	Stephens, John Gower, M.B., Royal Prince Alfred Hospital, Camperdown.
1913		Stewart, Alex. Hay, B.E., 'Yunah,' 22 Murray-street, Croydon
1900	P 1	Stewart, J. Douglas, B.V.Sc., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; p.r. 'Berelle,' Homebush Road, Strathfield. (President 1927.) *Vice-President.*
1909		Stokes, Edward Sutherland, M.B. *Syd.*, F.R.C.P. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1916	P 1	Stone, W. G., Assistant Analyst, Department of Mines, Sydney.
1927		Stump, Claude Witherington, M.D., D.Sc., Assoc.-Professor of Anatomy in the University of Sydney; p.r. 40 Shirley-rd. Wollstonecraft.
1919		Stroud, Sydney Hartnett, F.I.C., Ph.C., c/o Elliott Bros., Ltd., Terry-street, Rozelle.
1920		Sulman, Sir John, Kt., Warrung-st., McMahon's Point, North Sydney.
1918		Sundstrom, Carl Gustaf, c/o Federal Match Co., Park Road, Alexandria.
1901	P 12	‡Sussmilch, C. A., F.G.S., F.S.T.C., A.M.I.E. (Aust.), Principal of the East Sydney Technical College, and Assistant Superintendent of Technical Education. (President 1922. *Hon. Secretary.*
1919		‡Sutherland, George Fife, A.R.C.Sc., *Lond.*, Assistant-Professor in Mechanical Engineering, in the University of Sydney.
1920		Sutton, Harvey, O.B.E., M.D., D.P.H. *Melb.*, B.Sc. *Oxon.*, 'Lynton,' Kent Road, Rose Bay.

Elected		
1919		Swain, Herbert John, B.A. *Cantab.*, B.Sc., B.E. *Syd.*, Lecturer in Mechanical Engineering, Technical College, Sydney.
1926		Tannahill, Robert William, B.Sc. *Syd.*, "Eastwell," 40 Cammaray Avenue, North Sydney.
1915	P 3	Taylor, Harold B., D.Sc., Kenneth-street, Longueville.
1921	P 2	Taylor, John Kingsley, Hawkesbury Agricultural College, Richmond; p.r. 16 Ferrier-street, Rockdale.
1905		‡Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 13 East Crescent-street, McMahon's Point, North Sydney.
1921	P 4	Taylor, Thomas Griffith, B.A., D.Sc., B.E., Professor of Geography in the University of Chicago.
1899		Teece, R., F.I.A., F.F.A., Wolseley Road, Point Piper.
1923		Thomas, David, B.E., M.I.M.M., F.G.S., 15 Clifton Avenue, Burwood.
1919		Thomas, John, L.S., 'Remeura,' Pine and Harrow Roads, Auburn.
1924		Thompson, Herbert William, 'Marathon,' Francis-st., Randwick
1913		Thompson, Joseph, M.A., LL.B., Vickery's Chambers, 82 Pitt-st.
1919		Thorne, Harold Henry, B.A. *Cantab.*, B.Sc. *Syd.*, Lecturer in Mathematics in the University of Sydney; p.r. Rutledge-st., Eastwood.
1916		Tillyard, Robin John, M.A., D.Sc., F.R.S., F.L.S., F.E.S., Chief Commonwealth Entomologist, Canberra, F.C.T.
1923		Timcke, Edward Waldemar, Meteorologist, Weather Bureau, Sydney.
1923		Tindale, Harold, Works Engineer, c/o Australian Gas-Light Co., Mortlake.
1923		Toppin, Richmond Douglas, A.I.C., Parke Davis & Co., Rosebery.
1879		Trebeck, P. C., "Boera," Queen-street, Bowral.
1925		Tye, Cyrus Willmott Oberon, Under Secretary for Public Works, Public Works Dept., Sydney; p.r. 19 Muston-st., Mosman.
1916		Valder, George, J.P., 43 Albert-street, Mosman.
1890		Vicars, James, M.E., Memb. Intern. Assoc. Testing Materials; Memb. B. S. Guild; Challis House, Martin Place.
1921		Vicars, Robert, Marrickville Woollen Mills, Marrickville.
1892		Vickery, George B., 9th Floor, Barrack House, Barrack-street, Sydney.
1903	P 5	Vonwiller, Oscar U., B.Sc., F.Inst.P., Professor of Physics in the University of Sydney. *Hon. Secretary.*
1924		Wade, Rev. Robert Thompson, M.A., Headfort School, Killara
1919		Waley, Robert George Kinloch, 63 Pitt-street.
1910		Walker, Charles, 'Lynwood,' Terry Road, Ryde.
1910		Walker, Harold Hutchison, Vickery's Chambers, 82 Pitt-st.
1879		Walker, H. O., 'Moora,' Crown-street, Granville.

Elected		
1919	P 1	Walkom, Arthur Bache, D.Sc., Macleay House, 16 College-st.
1903		Walsh, Fred., J.P., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, London; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; Regd. Patent Attorn. Comm. of Aust.; Memb. Patent Attorney Exam. Board Aust.; 4th Floor, Barrack House, Barrack-street, Sydney; p.r. 'Walsholme,' Centennial Park, Sydney.
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1918		Ward, Edward Naunton, Curator of the Botanic Gardens, Syd.
1913	P 4	Wardlaw, Hy. Sloane Halcro, D.Sc. *Syd.*, Lecturer and Demonstrator in Physiology in the University of Sydney.
1922		Wark, Blair Anderson, V.C., D.S.O., M.I.Q.C., c/o Thompson and Wark, T. & G. Building, Elizabeth-street; p.r. 'Braeside,' Zeta-street, Lane Cove, Sydney.
1921		‡Waterhouse, G. Athol, D.Sc., B.E., F.E.S., Curator of the Division of Economic Entomology, Canberra.
1924		Waterhouse, Leslie Vickery, B.E. *Syd.*, 6th Floor, Wingello House, Angel Place, Sydney.
1919		Waterhouse, Lionel Lawry, B.E. *Syd.*, Lecturer and Demonstrator in Geology in the University of Sydney.
1919	P 3	Waterhouse, Walter L., M.C., B.Sc.Agr., D.I.C., 'Hazelmere,' Chelmsford Avenue, Roseville.
1919		Watkin-Brown, Willie Thomas, F.R.M.S., Lucasville Road, Glenbrook.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, University Club, Castlereagh-street; p.r. 169 Avoca-street, Randwick.
1910		Watson, James Frederick, M.B., Ch.M., 'Midhurst,' Woollahra.
1911	P 1	Watt, Robert Dickie, M.A., B.Sc., Professor of Agriculture in the University of Sydney. (President, 1925). *Vice-President.*
1920	P 22	Welch, Marcus Baldwin, B.Sc., A.I.C., Economic Botanist, Technological Museum.
1920	P 1	Wellish, Edward Montague, M.A., Associate-Professor in Mathematics in the University of Sydney.
1921		Wenholz, Harold, Director of Plant Breeding, Department of Agriculture, Sydney.
1881		‡Wesley, W. H., London.
1922		Whibley, Harry Clement, 39 Moore-street, Leichhardt.
1909	P 3	‡White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teacher's College.
1918		White, Edmond Aunger, M.A.I.M.E., c/o Electrolytic Refining and Smelting Co. of Australia Ltd., Port Kembla, N.S.W.
1892	P 2	White, Harold Pogson, F.C.S., Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1923		Whitehouse, Frank, B.V.Sc, (Syd.) 'Dane Bank,' Albyn Road, Strathfield.
1927		Wilkinson, Herbert John, B.A., M.B., Ch.M., Senior Lecturer and Demonstrator in Anatomy in the University of Sydney, p.r. 53 Liverpool Road, Summer Hill.
1921		Willan, Thomas Lindsay, B.Sc., c/o Alluvial Tin Malaya Ltd., Ho Hong Bank Bld., Market and Beach Streets, Penang, Straits Settlements.
1920		Williams, Harry, A.I.C., c/o Whiddon Bros.' Rosebery Lanolines Pty. Ltd., Arlington Mills, Botany.

Elected		
1924		Williams, William John, 18 Bridge-street, Sydney.
1923		Wilson, Stanley Eric, 'Chatham,' James-street, Manly.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 11	Woolnough, Walter George, D.Sc., F.G.S., 'Callabonna,' Park Avenue, Gordon. (President, 1926.) *Vice-President.*
1916		Wright, George, c/o Farmer & Company, Pitt-street.
1917		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry in the University of Sydney.
1921		Yates, Guy Carrington, 184 Sussex-street.

Honorary Members.

Limited to Twenty.

M.—Recipients of the Clarke Medal.

1918		Chilton, Charles, M.A., D.Sc., M.B., C.M., etc., Professor of Biology, Canterbury College, Christchurch, N.Z.
1914		Hill, James P., D.Sc., F.R.S., Professor of Zoology, University College, London.
1908		Kennedy, Sir Alex. B. W., Kt., LL.D., D. Eng., F.R.S., Emeritus Professor of Engineering in University College, London, 17 Victoria-street, Westminster, London S.W.
1915		Maitland, Andrew Gibb, F.G.S., Government Geologist of Western Australia, 'Bon Accord,' 2 Charles-street, South Perth, W.A.
1912		Martin, C. J., C.M.G., D.Sc., F.R.S., Director of the Lister Institute of Preventive Medicine, Chelsea Gardens, Chelsea Bridge Road, London, S.W. 1.
1894	M	Spencer, Sir W. Baldwin, K.C.M.G., M.A., D.Sc., F.R.S., Emeritus Professor of Biology in the University of Melbourne, National Museum, Melbourne.
1928		Smith, Grafton Elliott, M.A., M.D., F.R.S., F.R.C.P., Professor of Anatomy in the University College, London.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., LL.D., Sc.D., F.R.S., The Ferns, Witcombe, Gloucester, England.
1915		Thomson, Sir J. J., O.M., D.Sc., F.R.S., Nobel Laureate, Master of Trinity College, Cambridge, England.
1921		Threlfall, Sir Richard, C.B.E., M.A., F.R.S., lately Professor of Physics in the University of Sydney, 'Oakhurst, Church Road, Edgbaston, Birmingham, England.
1922		Wilson, James T., M.B., Ch.M. *Edin.*, F.R.S., Professor of Anatomy in the University of Cambridge, England. 31 Grange Road, Cambridge, England.

Obituary 1928-29.

Ordinary Members.

Elected.		Elected.	
1904	Cambage, Richard Hind	1887	MacCulloch, Stanhope H.
1876	Cape, Alfred John	1897	Russell, Harry Ambrose
1876	Darley, Cecil West	1913	Scammell, William Joseph
1922	Fleming, Edward Patrick	1899	Teece, Richard
1881	Knibbs, George Handley	1917	Willington, William Thomas

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. WILLIAM BRANWHITE CLARKE, M.A., F.R.S., F.G.S., etc.

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

Awarded

1878 *Professor Sir Richard Owen, K.C.B., F.R.S.
1879 *George Bentham, C.M.G., F.R.S.
1880 *Professor Thos. Huxley, F.R.S.
1881 *Professor F. M'Coy, F.R.S., F.G.S.
1882 *Professor James Dwight Dana, LL.D.
1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S.
1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.
1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1886 *Professor L. G. De Koninck, M.D.
1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.
1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.
1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.
1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.
1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.
1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., Sc. D., F.R.S., F.L.S., late Director, Royal Gardens, Kew.
1893 *Professor Ralph Tate, F.L.S., F.G.S.
1895 *Robert Logan Jack, LL.D., F.G.S., F.R.G.S.
1895 *Robert Etheridge, Jnr.
1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.
1900 *Sir John Murray, K.C.B., LL.D., Sc.D., F.R.S.
1901 *Edward John Eyre.
1902 *F. Manson Bailey, C.M.G.. F.L.S.
1903 *Alfred William Howitt, D.Sc., F.G.S.
1907 Walter Howchin, F.G.S., University of Adelaide.
1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.
1912 *W. H. Twelvetrees, F.G.S.
1914 A. Smith Woodward, LL.D., F.R.S., Keeper of Geology, British Museum (Natural History) London.
1915 *Professor W. A. Haswell, M.A., D.Sc., F.R.S.
1917 Professor Sir Edgeworth David, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., The University, Sydney.
1918 Leonard Rodway, C.M.G., Honorary Government Botanist, Hobart, Tasmania.
1920 *Joseph Edmund Carne, F.G.S.
1921 *Joseph James Fletcher, M.A., B.Sc.,
1922 Richard Thomas Baker, The Crescent, Cheltenham.
1923 Sir W. Baldwin Spencer, K.C.M.G., M.A., D.Sc.. F.R.S., National Museum, Melbourne.
1924 *Joseph Henry Maiden, I.S.O., F.R.S., F.L.S., J.P.
1925 *Charles Hedley, F.L.S.
1927 Andrew Gibb Maitland, F.G.S., "Bon Accord," Melville Place, South Perth.
1928 Ernest C. Andrews, B.A., F.G.S., Government Geologist, Depart- of Mines, Sydney.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

1882 John Fraser, B.A., West Maitland, for paper entitled 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong. for paper entitled 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper entitled 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper entitled 'The Tin deposits of New South Wales.'

1887 Jonathan Seaver, F.G.S., Sydney, for paper entitled 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.'

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper entitled 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for paper entitled 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.'

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper entitled 'The Australian Aborigines.'

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper entitled 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper entitled 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper entitled the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper entitled 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, D.Sc., M.B., F.R.S., Sydney, for paper entitled 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper entitled 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS

By Professor J. Douglas Stewart, B.V.Sc., M.R.C.V.S.

Delivered to the Royal Society of New South Wales, May 2, 1928.

During the past year the Council has held eleven meetings, of which ten were ordinary meetings and one a special meeting to consider the terms of purchase of the Royal Society's House. The average attendance at the Council Meetings was twelve.

At the eight monthly meetings of the Society twenty-three papers were read. They covered a wide range and added materially to scientific knowledge. In his Presidential address last year Dr. W. G. Woolnough drew attention to the smallness of the attendance at the monthly meetings and made several suggestions "to promote greater interest and wider mutual understanding and appreciation". These suggestions were considered by the incoming Council, and after due deliberation it was decided that authors should read papers in abstract and, if possible, introduce into them a popular element to interest all members attending monthly meetings, fuller consideration of papers to be given at section meetings when desired; that abstracts be supplied beforehand to members desiring them so that they might be better able to discuss the paper; that a lecturette or demonstration of somewhat general character be arranged for each monthly meeting; and that the Executive Officers be empowered to arrange the business of the meeting. Consequently, in addition to the papers read, the following lecturettes were given at the monthly meetings:—"The Minute Sediment Test for

Milk" by Robert Grant, F.C.S., "Agriculture and Research in Java" by Professor R. D. Watt, M.A., B.Sc., "Newton" by Professor O. U. Vonwiller, B.Sc., F.Inst.P., last year being the bi-centenary of the death of Sir Isaac Newton, and "Development of Liver Fluke" by I. Clunies Ross, B.V.Sc., with cinema views by Visual Education Ltd. Several interesting exhibits and demonstrations were given also, including a photo-negative of the star cluster Omega Centauri and some plates made in preparation of the Great Photographic Star Catalogue by J. Nangle, O.B.E., F.R.A.S., cinematograph records of heart-beats by stethoscope and hot-wire microphone by E. H. Booth, M.C., B.Sc., F.Inst.P., and cinema views of the preparation of the Biological Products, loaned by Messrs. Parke, Davis & Co. It would appear that the innovation was appreciated by members, as the attendance at the monthly meetings progressively increased during the year, and greater interest was manifested in the proceedings.

The sections of the Society held meetings as follows:—Geology 7, Agriculture 2, and Physical Science 7. Instead of holding meetings, the Section of Industry visited different manufacturing establishments on seven occasions.

Four Popular Science Lectures were delivered during the year as follows:—

June 16: "A Glance at Japan," by R. H. Cambage, C.B.E., F.L.S.

July 21: "Earth Waves and Earth Ripples," by Edgar H. Booth, M.C., B.Sc., F.Inst.P.

August 18: "Some Observations on Disease in Plants," by R. J. Noble, B.Sc. (Agric.), Ph.D.

September 15: "What Makes a Good Food," by Professor H. G. Chapman, M.D.

Also an interesting lecture was given by Dr. Rudolf Krahmann, Lecturer on Engineering Science and Geophysics in the Technical University of Berlin, on Monday, 31st October, 1927, in which new applications of physical science to survey the earth's crust were demonstrated and their limitations explained.

During recent years it has become abundantly evident that the increasing noise of the street traffic of Elizabeth Street has made it desirable for the Society to acquire premises in some quieter locality, and as the Government made available a block of land situated at the corner of Gloucester and Essex Streets in the Observatory Hill area of the city, for the erection of a building to house scientific bodies, the Council entered into negotiations for the sale of the Royal Society's House, which it has occupied since 12th May, 1875, and owned since 31st July, 1878. On the 21st October, 1927, the sale was effected under advantageous terms, chiefly through the good services of the Honorary Treasurer, Professor H. G. Chapman, to the Adult Deaf and Dumb Society for the sum of £28,000, and arrangements were made for the Royal Society to retain the use of the present building, excepting the first floor, until 31st December, 1928, on satisfactory conditions. The Council regarded the gift of the Government as a very fine contribution to science and expressed its appreciation to the then Premier, the Hon. J. T. Lang. Unfortunately, a delay, which was not anticipated, has occurred in the transfer of the new site, and a committee consisting of representatives of the Royal Society, the Linnean Society and the Institution of Engineers is giving the matter attention. The change in ownership of the Royal Society House has caused some unavoidable inconvenience to tenants, and the forebearance they have shown is greatly appreciated. The plans for the proposed Science House are under consideration.

During the year twelve new members were elected; eight members have resigned and twelve have died. Among those that resigned were Professor J. Kenner, who accepted appointment to the Chair of Technological Chemistry in the University of Manchester, and Mr. J. K. Taylor, who joined the staff of the Waite Research Institute, South Australia. Unfortunately, the list of deaths includes the names of our oldest member (1872), three out of the group of six next oldest members (1876), two past Presidents, our late Honorary Secretary, and other members eminent in science. The number of members of the Society is now 344.

Robert Houston Barr, elected 1918, died 18th September, 1927. Mr. Barr was born in Scotland, and served his engineering apprenticeship with Vickers, Sons and Maxim, of Burrow-in Furness. He was a Whitworth scholar, and, coming to Australia in 1914, he built up an extensive practice as consulting engineer. He was also a member of the Institution of Engineers of Australia.

Andrew John Brady, L.K. & Q.C.P. Irel., L.R.C.S. Irel. Elected 1876, died 25th August, 1927. Dr. Brady was an Ulster man by birth, and a graduate of the Royal College of Surgeons, Dublin. He came to Australia over fifty years ago and soon became identified with the Sydney Hospital as Resident Medical Officer (1875), and subsequently as Hon. Surgeon and Specialist. At the time of his death he was President of the Sydney Hospital. For many years Dr. Brady had been recognised as one of the leading members of the medical profession in Sydney. He always manifested a keen interest in the affairs of the Royal Society.

Alfred John Cape, elected 1876, died 29th April, 1928. Mr. Cape was one of the most notable members of the legal profession in New South Wales. He graduated as

Master of Arts at Sydney University in 1867. He was one of the oldest trustees of the Sydney Grammar School, having been first nominated in 1877, and has laboured unceasingly to foster the traditions of the school.

Eustace William Ferguson, M.B., Ch.M., elected 1920, died 18th July, 1927. A son of the late Rev. J. Ferguson, formerly of St. Stephen's Church, Phillip Street, Dr. Ferguson was born at Invercargill, N.Z., in 1884. He graduated with Honours, Sydney University, 1908, and joined the Department of Public Health in 1913. From 1915 to 1918 he served with the Army Medical Corps in France and Palestine. In 1920 he succeeded Professor Cleland as Micro-biologist of the Department of Public Health, and in 1926 was awarded the Diploma in Public Health. In 1922 he was elected President of the Royal Zoological Society of N.S.W., and in 1926 President of the Linnean Society, N.S.W., of which he had been a member since 1909.

Dr. Ferguson was one of our most prominent naturalists and was a recognised authority on medical entomology. He contributed many papers to various scientific societies in Australia. Of late years he worked on the classification of the Australian Diptera—chiefly *Tabanidae* and *Syrphidae*—and considerably advanced knowledge. Of especial value was his work in connection with the relationship of flies to the spread of disease. When attacked by his fatal illness he was actually engaged in writing an able presidential address, "A Review of Medical and Veterinary Entomology in Australia."

Robert Greig-Smith, D.Sc., elected 1899, died 6th August, 1927. Dr. R. Greig-Smith, Macleay Bacteriologist to the Linnean Society of New South Wales, was born at Edinburgh in 1866, and educated at George Watson's College. At the University of Edinburgh he won the

medal in Chemistry, the special prize in senior Botany, and first-class honours and prizes in other subjects. In 1890 he took the degree of B.Sc., and was appointed Lecturer in Agricultural Chemistry in the Durham College of Science. Later, he was Assistant Lecturer in Chemistry at the Royal (Dick) Veterinary College, Edinburgh. He studied Micro-biology in Edinburgh, Bonn, Newcastle-on-Tyne and Copenhagen. By vote of convocation he was awarded M.Sc. (Durham), and in 1903 graduated as Doctor of Science at Edinburgh University, presenting a thesis on certain fermentations of saccharose. In 1906 he was President of the Pathological Club of Sydney, in 1907 President of Sanitary Science and Hygiene section of the Australasian Association for the Advancement of Science, and in 1906-8 Chairman of the Sydney section of the Society of Chemical Industry. He was President of the Royal Society of New South Wales in 1917, and one of its Honorary Secretaries from May, 1925, to August, 1927. He published numerous papers in connection with research in general, economic and pathological bacteriology. The services Dr. R. Greig-Smith gave in the advancement of science generally, and to the welfare of this Society, were of signal value.

Launcelot Harrison, B.A. Cantab., B.Sc., Syd., elected 1919, died 20th February, 1928. Professor Launcelot Harrison was the eldest son of the late Dr. Thomas Harrison, of Sydney. He was born at Wellington, N.S.W., and educated at the King's School, Parramatta, where for two years he was head of the school and Broughton Scholar. In 1914 he graduated as B.Sc., Sydney University, with high distinction, and was awarded the University Medal and Professor Haswell's prize in Zoology. In addition, he took Honours in Botany and the Dun Prize in Paleontology (1912). He acted as Demonstrator in Zoology and Botany,

1913, and he was awarded the John Coutts Scholarship for Distinction in Science, 1914. In the same year he won the Exhibition of 1851 Science Research Scholarship, and proceeding to England, he gained the open Graduate Exhibition for Research at Emmanuel College, Cambridge. In 1916 he was awarded the degree of Bachelor of Arts (Research), Cambridge, and proceeded to Mesopotamia as Advisory Entomologist to the Expeditionary Forces there, with the rank of Lieutenant. The work he accomplished in preventing the communication of insect-bearing diseases was of far-reaching importance, and he was promoted to the rank of Captain. While on active service in 1918 he was appointed Lecturer and Demonstrator in Zoology at the Sydney University, the duties of which he took up in July, 1919. In 1920 he acted as Professor in Zoology and was appointed to the Chair in 1923. He was President of the University Union, 1920-21, and took an active part in the University Science Society. During recent years he was elected President of the Royal Zoological Society, N.S.W., and at the time of his death he was President of the Linnean Society, N.S.W. Professor Harrison was an untiring worker with a genuine love of learning, and an enthusiastic teacher of striking personality. It was in Mesopotamia that he contracted his fatal illness, and for several years he resolutely carried on, notwithstanding the pain and inconvenience he at times suffered.

THOMAS WILLIAM KEELE, L.S., M.Inst.C.E., elected 1876, died June 18th, 1927. For fifty-four years Mr. T. W. Keele was a member of the Public Service of New South Wales, during which time he filled many important engineering positions in the Public Works Department. He was appointed a member of the Royal Commission on the Water Supply of Sydney in 1902, and originated the proposal of the construction of the Cataract Dam. He carried out

very valuable work in connection with many schemes for water conservation, water supply and sewerage, and was associated with the majority of large harbour works along the coast. On his retirement from the Public Service he was elected a member of the Water and Sewerage Board, and subsequently became President. He was also a member of the Sydney Harbour Trust.

ARCHIBALD LIVERSIDGE, M.A., LL.D., F.R.S., elected member 1872, and Honorary Member 1908, died 26th September, 1927, in his 80th year. Professor Liversidge was born at Turnham Green on November 17th, 1847, and received his first instruction in science from private tutors. In 1866 he entered the Royal College of Chemistry and the Royal School of Mines, at which, in the following year, he won a Royal Exhibition and medals in Chemistry, Mineralogy, and Metallurgy. In his first year at the Royal College of Chemistry he was placed in charge of the chemical laboratory at the Royal School of Naval Architecture for one term, during the illness of the lecturer, and published his first paper on "Supersaturated Saline Solutions". Professor Frankland was his teacher at the College of Chemistry and at the School of Mines, the associateship of which he obtained in 1870, his teachers were Professor Tyndall in Physics, Sir Andrew Ramsay in Geology, Sir W. Warington Smyth in Mineralogy and Mining, Professors Willis and Goodeve in Mechanics, and Dr. Percy in Metallurgy. As a senior student he also did research work in Dr. Frankland's private laboratory. In 1870 Liversidge was elected to an open scholarship in Science at Christ's College, Cambridge. He was one of the first two students in the physiological laboratory just started by Professor Michael Foster, and during his first year at Cambridge he held the post of Demonstrator in Chemistry at the University Laboratory for two terms in the absence of Dr. Hicks.

Liversidge thus seemed destined to a career of high distinction at Cambridge, but in 1872, before he was 25, he accepted the Chair of Chemistry and Mineralogy in the University of Sydney, N.S.W. He came out in September, 1872, and from that time till his retirement with the title of Emeritus Professor, in December, 1907, his services to science in Australia were of much value. Chief among them was the founding of the Australasian Association for the Advancement of Science in 1885 as a centennial record of the progress of the colonies, and of which he was Hon. Secretary for many years and President 1888-90. In 1874 he was made a trustee of the Australian Museum at Sydney, and during visits to Europe, America and the East brought together the greater part of its non-Australian mineral and geological collections. Of the Royal Society of New South Wales he was Hon. Secretary for 13 years, 1874-1884, and 1886-1888, and served three terms of office as President, 1885, 1889, 1900, being also for many years the editor of the Society's Journal. He originated the Faculty of Science at the Sydney University, 1879, and was Dean till 1904, and also a member of the Senate. He founded the School of Mines in that University in 1890, also the Sydney section of the Society of Chemical Industry in 1902, and was the first Chairman. He was a member of the original board of three of the Sydney Technological Museum and of the first Board of Technical Education in Sydney. Professor Liversidge made a chemical investigation of the Sydney water supply for the Government in 1876. In 1888 he published a survey of the minerals of New South Wales, and he was the author of over 100 papers and researches published by the Royal Society, the Chemical Society, and the Royal Society of New South Wales.

Professor Liversidge was elected a Fellow of the Royal Society of London as far back as 1882, and he was also an Honorary Fellow of the Royal Society of Edinburgh, Vice-President of the Chemical Society, 1910-13, and of the Society of Chemical Industry, 1900-12, a member of the Cambridge Philosophical Society, the Physical Society of London, the Mineralogical Societies of Great Britain and France, and a member or corresponding member of various colonial and foreign scientific societies. He was Hon. LL.D. of Glasgow University. Truly a wonderful record in the cause of Science. To the Royal Society of New South Wales he was much attached, and his last service was to bequeath to it all his medals and diplomas, together with a sum of £500 to found a Research Lectureship in Chemistry.

In his history of the Royal Society of New South Wales, Mr. J. H. Maiden wrote: "We owe the acquisition of this House to the Council of the day, and especially to the then two honorary secretaries, Professor Liversidge and Dr. Leibius, but the principal driving power was that of Professor Liversidge, who workd whole-heartedly for the advancement of the Society from the very day he became a member of it." Mr. Maiden quotes Dr. Leibius as saying: "We never got a move on till Liversidge came." (This Journal, Vol. LII., 1918.)

Ebenezer MacDonald, J.P., elected 1878, died 4th July, 1927. Mr. MacDonald was well-known in commercial and banking circles during last century. On his retirement he lived in England, but kept in close touch with Australian affairs.

William Joseph Scammell, elected 1913, died 19th April, 1928. Mr. Scammell was born in South Australia and as a youth went to London to study Pharmacy. Later he became a member of the British Pharmaceutical Society.

George Augustine Taylor, elected 1925, died 20th January, 1928. The late Mr. George A. Taylor was noted for his versatility. He was one of the early workers in the development of wireless telegraphy, founding the Wireless Institute in 1911, and the Association for the Development of Wireless 1922. The transmission of colour photography by wireless also received his attention. He was among those who formed the New South Wales Aerial League in 1909. He was associate member of the Institute of Engineers, and Fellow of the Royal Geographical Society and of the Royal Astronomical Society. He was owner-editor of "Building", and the success of this magazine encouraged him to further journalistic ventures, covering a wide range.

James Taylor, B.Sc., A.R.S.M., F.G.S., elected 1893, died 14th December, 1927, in his 78th year. Mr. Taylor was born at Oldham, England, and trained as an engineer; he was one of the earliest Whitworth Scholars in Engineering. He entered Owen's College, Manchester University, of which he was Dalton Scholar in Mathematics. He then became assistant to Sir Henry Roscoe, and worked out some of the earliest formed compounds of the newly-discovered element vanadium. In 1880 he became associate of the Royal College of Mines in London, and in 1892 he was appointed Government Metallurgist of this State. In 1900 he resigned, and for many years was engaged in mining and metallurgical work in Australia. Mr. Taylor was also a member of the Chemical Society and the Institute of Mining and Metallurgy. He was for some time Lecturer in Metallurgy at the University of Sydney.

William Welch, F.R.G.S., elected 1907, died 5th April, 1928. Mr. Welch was born at Portsmouth in 1850, and for some years was attached to the Admiralty. He migrated to New Zealand, where he resided 22 years, during which

he founded the Museum at Palmerston North, and he was also instrumental in founding the Philosophical Society at Manawatu. Coming to Sydney, Mr. Welch took a keen interest in the affairs of the Royal Australian Historical Society. For fourteen years he acted as its Honorary Treasurer, and for some years carried out the indexing and tabulating of its historical results. He took an active part in raising funds for the building of an historical museum.

THE MAIDEN MEMORIAL.—It will be remembered that Professor Watt in his presidential address, 1926, suggested that an effort might be made to commemorate in a fitting manner the life and work of the late Mr. J. H. Maiden, who for many years was Director of the Botanical Gardens and Government Botanist of this State. With this object in view, a public meeting was called by the Royal Society, at which a Committee was elected and a subscription list opened to obtain funds. It was considered that a fitting way of perpetuating the memory of Mr. Maiden would be to erect a building to be known as the "Maiden Memorial Pavilion" in the Sydney Botanical Gardens, where he had spent so many useful and happy days. Subsequently a design for a suitable building was prepared by the Government Architect, and the cost estimated at about £1,000. While response to the appeal for requisite funds has been fairly generous, the amount so far subscribed hardly reaches £350. Consequently the Committee has been compelled to ask the Government Architect for a further design, which has been approved tentatively. The pavilion it is now proposed to erect will cost something in the neighbourhood of £750, and with a view to expediting erection a special appeal to the friends and admirers of the late Government Botanist for further funds is being made.

THE BURFITT PRIZE.—With reference to the generous donation of £500 by Dr. Walter F. Burfitt, a member of

this Society, it has been decided to use the capital sum for the foundation of a prize to be awarded annually by the Council at its discretion to a person resident in Australia or New Zealand who in its opinion has done meritorious work in the cause of science.

CLARKE MEMORIAL MEDAL.—During the year Mr. E. C. Andrews, B.A., F.G.S., delivered by invitation the Silliman Foundation Lectures at the Yale University, U.S.A. He also attended the second Empire Mining Congress held during August last in Canada, and represented this Society in October at the celebration of the centenary of the granting of a Royal Charter to King's College, Toronto. Mr. Andrews has been honoured further by having the Clarke Memorial Medal awarded to him, in recognition of his past services in the advancement of science, more particularly in Geology.

The work of the Australian National Research Council, which deals mainly with matters relating to pure science, has proceeded throughout the year. As the result of several grants made to the Council by the Rockefeller Foundation, investigations are being carried out in regard to the aborigines of Australia and some of the native races of the Pacific. This Council also has in hand the making of arrangements for a Scientific Expedition to Mandated Territory and Papua, which it is thought will be made in 1929.

The fourth Pacific Science Congress is to be held in Java during May and June, 1929, and the Research Council has been asked to arrange for a suitable delegation of prominent scientists from Australia.

The nineteenth meeting of the Australasian Association for the Advancement of Science was held at Hobart in January, 1928, and was well attended. Many important papers were read, and much interest was taken in the

various discussions by the sections. The scientific institutions and departments of the different States were well represented, and the President, Mr. R. H. Cambage, C.B.E., F.L.S., is to be congratulated on the success attained.

Owing to the pressure of other duties, Mr. Cambage has been compelled to decline nomination as Senior Honorary Secretary of the Society this year, and the Council has placed on record its high appreciation of his services in this capacity. Mr. Cambage was first elected to the position in 1914, and, with the exception of a break of two years during the first of which he was President of this Society, and during the second President of the Linnean Society of New South Wales, he has continuously carried out the duties with great devotion and marked assiduity.

We congratulate Sir Richard Threlfall, K.B.E., upon the additional honour His Majesty the King has been pleased to confer upon him.

THE APPLICATION OF SCIENCE TO THE SHEEP INDUSTRY.

At the year of Federation, 1901, the National Debt of the Australian States represented a per capita liability of £53/13/9. On 30th June, 1926, the total Public Debt of Australia (Federal and State) represented a per capita burden of £167/9/8, a three-fold increase in a little over twenty-five years! In his Joseph Fisher Lecture, delivered at Adelaide last year, the Prime Minister, Mr. S. M. Bruce, P.C., stressed the necessity for prudent and efficient control of national revenue, a larger population, and increased production.

In order to provide more population, particularly in rural areas where it is most needed, and to stimulate production, it is essential to encourage the development of

our primary industries. Of these, pastoral production contributes most to our revenue, and the chief factor in our pastoral wealth is the sheep industry. For the season ending 30th June, 1926, the wool output was valued at £61,404,000,[1] and the 15% of the mutton and lamb treated that was exported during the same period came to £2,430,465. Much further revenue is derived from other sources, but the figures given are sufficiently impressive to show the importance of our sheep industry.

Australia has long occupied the leading position among the sheep-raising countries of the world, not only in regard to the number of sheep she possesses, but also with respect to the quantity and quality of wool she produces. It is essential for her prosperity that this pre-eminence be maintained by further development, and the directions in which advancement is desirable are many. They cover a wide range, from production to marketing, and the object of this address is to indicate some of the ways in which science can assist production by solving certain problems that are retarding progress.

As many of the problems of our pastoral industries are primarily due to the peculiar physiographical characteristics of Australia, it is deemed necessary to refer briefly to the more important in order that the exact nature of some of the difficulties our pastoralists have to contend with, may be better understood. An outstanding characteristic in the topography of Australia is the Great Peneplain which forms most of Western Australia, the Northern Territory, and western South Australia, or more than half the Continent.[2] It is essentially a rather low plateau about 1,200 feet above sea level, and on the whole poorly supplied with rainfall. In the eastern portion of the Continent more localised uplifts have taken place, leading to the formation of the belt of highlands which

extends from north to south along the coast. Between the western peneplain and the eastern cordillera is a region of lower land, that at Lake Eyre having sunk below sea level. As the result of this peculiar conformation, the majority of the permanently flowing rivers radiate from the plateaux to the sea and are relatively of no great size or length. The only big permanently flowing river of the Continent is the Murray, which by means of its branches (the Murrumbidgee, Lachlan and Darling) drains the western side of the eastern plateaux in Queensland, New South Wales and Victoria, and flows through the south-east of South Australia into the Southern Ocean. Some other rivers such as the Georgina, Diamantina and Cooper, which traverse the low-lying central portion of the Continent, are normally dry, but in the wet seasons they pour a considerable volume of water into inland lakes and swamps.

About five-thirteenths of Australia lies within the tropics, and the "temperate" region is half as large again.[3] In the latter, along the east coast the highlands reach altitudes up to a little over 7,300 feet. The extreme range of shade temperatures in summer and winter in a very large part of Australia amounts to probably only 81°, which relatively is not great. Along the northern shores the temperatures are very equable, but coming southward the extreme range increases gradually on the coast and in a more pronounced manner inland. In the interior of Australia during exceptionally dry summers the temperature may reach and occasionally exceed 120° F. in the shade. It would appear that the hottest area is situated in the northern portion of Western Australia, about Marble Bar, and that the coldest part of Australia is in the extreme south-east of New South Wales and the extreme east of Victoria. During a dry winter the major portion of the country to the south of the tropics is subject to ground

frost. On the whole, much of the climate is suitable for the breeding of sheep and the production of high-class wool.

With a land block of nearly three million square miles surrounded by sea and possessing such peculiar topographical features, as is to be expected, the distribution of rainfall throughout Australia is variable, both in degree and in incidence, and the rate of evaporation has a wide range. The wettest known part of Australia is on the north-east coast of Queensland, with an average annual rainfall of over 100 inches, while the driest part is in the region of Lake Eyre, where the annual average is only 5 inches, and where the fall rarely exceeds 10 inches for the twelve months. In general terms, approximately one-third of the area of the Continent, principally the eastern and northern parts, enjoys an average rainfall of from 20 to 50 or more inches, the remaining two-thirds averaging from 5 to 20 inches. The area receiving less than 10 inches is about 36% of the whole, or about 82% of the area of South Australia, 50% of Western Australia, 27% of the Northern Territory, 15% of New South Wales, and 12% of Queensland.

The average amount of yearly rainfall, however, gives no indication as to its reliability, since much variation may occur from year to year. As examples of the extent of the variation that sometimes takes place, Barrow Creek with 39 inches in 1904 and 4 inches in 1925, Onslow with 27 inches in 1900 and but 3 inches in 1901, have been cited, and equally illuminating are the following records of a Queensland station:—1921, 1222 points; 1922, 100 points; 1923, 325 points; 1924, 803 points; 1925, 299 points; 1926, 353 points; and 1927, 136 points.[4] From the map shown by Professor Griffith Taylor,[5] it will be seen that in the southern part, portion of the eastern part and in the extreme north of the Continent the yearly

rainfall is reliable, while in the centre of Australia it is very unreliable. Between these two an intermediate zone, chiefly pastoral, exists, where the rainfall is again considered unreliable. The fact that the rainfall in the major portion of Australia is unreliable must be recognised.

As the fluctuations in rainfall vary greatly, the dry spells resulting from diminished rainfall are inconstant both in extent and degree. Sometimes small areas are affected for short periods during which even neighbouring districts enjoy satisfactory rainfall; occasionally large areas, extending often into adjoining States, are affected for long periods. When diminished rainfall becomes associated with continued high temperatures and drying winds, the condition known as "drought" becomes established, which, unfortunately, is not of uncommon occurrence.

The Sheep Industry.

Its Growth.—It would appear that sheep were brought to Australia either by the First Fleet or by some of the vessels that closely followed, as the number of sheep given in the live stock account of the new colony for year 1788 was 29.[6] During the first few years of settlement the number did not increase much, as the returns of 1791 gave it as 57.[7] Evidently this supply was not considered sufficient for the food requirements of the growing settlement, and several consignments were brought from India and South Africa. As a result, the returns of 1795 show an increase to 832.[8] It was during the previous year that the attention of Captain John McArthur had been attracted to the possibility of fine wool production in Australia by observing the improvement in the fleece of some lambs got by crossing the hair-bearing sheep from Bengal with a British breed brought by a transport ship from Ireland.

This observation marked the initial stage of our wool-producing industry, but the foundation of the industry is generally regarded as having been laid when the Spanish merino was introduced from South Africa in 1797, and their progeny demonstrated the practicability of producing in Australia fine wool of excellent quality. A third signal event in early history was the crossing of the Blue Mountains by Wentworth, Lawson and Blaxland in 1813, and the subsequent discovery by Evans of the fertile plains beyond, which allowed expansion of settlement from the confined area of the County of Cumberland (N.S.W.). As a result, sheep increased rapidly in numbers—the 6,514 in 1813 became 119,777 in 1821—and, as the wool grown equalled that produced in Spain, much encouragement was given officially to the new industry, especially by facilitating land occupation. Incessant demand for fresh pastures led to extensive exploration. Occupation went on apace, the sheep population multiplied rapidly, and the great industry became well established, but not without receiving many checks, the chief causes of which were the devastations wrought by drought, the slumping of values abroad and the overseas transportation difficulties of last century.

Distribution of Sheep.—The official returns for the year 1925 show that Australia then possessed 103,563,218 sheep, distributed, approximately, 52% in New South Wales, 20% in Queensland, 13% in Victoria, 7% in South Australia, 7% in Western Australia, and 1% elsewhere. The area of concentration in New South Wales commences above the 65° F. isotherm, and runs south-west on either side of the 20 inch line of annual rainfall into Victoria.[9] East of the belt of highlands, where the average annual rainfall is 40 inches or over, very few flocks of any size are found, and on the other side of the range the sheep population diminishes gradually from the western slopes

through the inland plains towards the border of South Australia, the most sparsely populated area being the far north-west corner. Sheep runs in Victoria extend fairly well over the whole State, with the exception of the north-western corner of the mallee country in the north-west. Some degree of concentration has occurred in Queensland about the Longreach district, and numerous sheep runs are scattered about a large area of country north and south of this centre, but they do not invade the wet coastal area in the east, or the tropical region much above the 75° F. isotherm in the north. During the year 1925 the Northern Territory contained only slightly more than 8,000 sheep. In South Australia the sheep concentration is greatest in the extreme south-eastern corner, the York Peninsula, and the southern drift of the River Murray, where the average rainfall is about 20 to 30 inches. From these areas it winds northward along the Lofty and Flinders Ranges, and markedly diminishes within the 10 inch rainfall boundary. Along the coast of the Great Australian Bight there are scattered sheep runs south of the 10 inch rainfall isohyet. In Western Australia the greatest concentration exists in the south-western corner of the Continent, whence occupation extends to a limited extent northward along the coast and even within the 10 inch rainfall line. It is of interest to note that while sheep are not numerous beyond the 75° isotherm in Queensland, several sheep runs have been established about Derby (W.A.), which is considerably above the 80° F. isotherm. Rainfall seems to have exercised a greater influence on distribution than heat.

Throughout Australia the Merino breed of sheep predominates. In areas receiving from 20 to 10 inches (or even less) of rainfall per annum it is practically the only breed existing, but in areas of 20 to 30 inches of rainfall where mixed farming is practised, English breeds such as

the Leicesters, the Lincoln, Romney Marsh and several Down varieties are commonly crossed with the Merino to supply the fat lamb and mutton trades. Of the 2,655,334 bales of wool sold locally during season 1925-6, 82.05% was classed as Merino, and 17.95% as coarse wool.

Extension of Sheep Occupation.—It may be accepted that as the result of extensive exploration, both official and private, practically the whole of that portion of Australia suitable for immediate profitable occupation has been taken up. What is regarded as the arid region of Australia includes about one million square miles, or about 36% of the Continent, and offers but little prospect for successful occupation at present; some, such as the Arunta Land and the Western Desert, will always be unattractive owing to its scanty and irregular rainfall and poor land. Surrounding this arid region is the Pastoral Zone, where the rainfall ranges from 10 to 20 inches, and a large portion of this still remains unoccupied owing to the lack of one or more, or maybe all, the essential factors for profitable occupation, such as a not too erratic rainfall, a serviceable supply of water, a soil capable of growing edible vegetation, and reasonable facilities for transportation. Over so extensive an area the relative importance of each of these factors varies considerably. In some parts the prospects do not appear encouraging; but in others, where the soil is sufficiently fertile to respond to the sporadic rains and a reasonable supply of water can be assured, extension of sheep occupation is regarded as practicable provided sufficient inducement is given by the State to wealthy individuals or companies by granting large holdings on long lease at a low rental. Sheep not only require a better class of country than cattle, but their care and management entails more supervision and a bigger outlay of capital in effecting improvements.

Apart from increased facilities for watering, and additional buildings (wool-sheds, etc.), more fencing is required, much of which may have to be netted. On many inland holdings the fight against rabbit invasion costs large sums annually, and on some the dingo pest has to be combated at considerable expense. The occupation of this class of country, which normally has a light carrying capacity (1 sheep to 10 to 20 acres), is not only costly but it often proves decidedly risky during prolonged dry spells. For successful occupation it must be made safer, and much can be done in reducing liability to failure by organised scientific team work, in which the meteorologist, the engineer, the chemist, the botanist, the agriculturalist, and the veterinary scientist can all give valuable aid in overcoming the difficulties associated with providing adequate water and food supply, breeding the most profitable type of sheep for special areas, suppressing diseases and pests, and facilitating transportation by extension of railway systems or by opening up new roads and stock routes. When systematic scientific effort under central direction is properly organised the extension of the pastoral area of Australia into the drier regions will no doubt be materially advanced. The necessity for this extension, particularly in the eastern portion of the Continent, is becoming more apparent each year owing to the expansion of agriculture absorbing many of the original large sheep holdings in more favoured areas, and the profitable utilisation of its lands is a matter no Government can afford to neglect indefinitely. Fresh country may be opened up by new railways, but for its development profitable occupation must be reasonably assured.

Fortunately, in addition to the acquisition of further pastoral areas, a material increase in sheep population is possible by the more intense occupation of the areas already in use. As previously pointed out, the greatest concentra-

tion of sheep population has taken place in areas receiving 18 to 30 inches of rainfall per annum, much of which is suitable for agriculture. In the early settlement of many countries the pastoral industry was all-important in stimulating occupation; then, as settlement advanced, crop-raising for a short time over-shadowed animal husbandry; but, as further development proceeded, the live stock industries again increased, and a sounder economic position ultimately became established by encouraging both the breeding of animals and the growing of farm crops. Australia has had a similar experience, and extension of the agricultural area, particularly by dry farming methods, has resulted in the maximum concentration of sheep population coinciding with the wheat belt where mixed-farming is carried on. In Australia mixed-farming usually means the growing of wheat and sheep. In areas distant from railway service, wool production is aimed at and the Merino predominates, but in districts where transportation is easier, and especially where additional fodder crops can be grown, the fat lamb and mutton trades are catered for by crossing the Merino with one of the British breeds. With the development of closer settlement this latter practice will increase, not only on account of the additional profit it yields, but also because the area of the farms usually limits the number of sheep that can be carried throughout the year. With cross-bred sheep the natural increase occurs when feed is usually abundant, and after selling off the lambs, only the ewes and a few rams need be carried over for next season. Still, with wool at the present prices, the tendency is to breed as close to the Merino as possible. Of recent years the dual purpose Corriedale breed (Merino x Lincoln) has come into much favour in agricultural areas. Some ten to twelve million sheep and

lambs are slaughtered annually, of which only about 15% is exported.

While recent advance in the control of parasitic affections has made it possible to run more sheep than hitherto in areas having over 30 inches of rainfall per annum, it is not likely that the increase here will be of any great importance.

It is evident from what has been stated that, while extension of sheep occupation is possible by further invasion of the drier areas, greater increase in sheep population is more likely to be brought about by better utilisation of areas having an average rainfall of 12 to 25 inches.

Increase in sheep population alone, however, will not advance the prosperity of the industry very far unless certain conditions retarding progress are better controlled, and improved methods of production are more actively stimulated. The general advancement of the industry, therefore, largely depends upon finding ways for preventing avoidable losses and for increasing production. From the following consideration of some of the more important problems and weaknesses of the industry, it will be seen that science must play an important part in future development.

The Control of Drought.

The term drought is a relative one. In Australia it is usually applied when the rainfall has been considerably below normal for fairly lengthy periods, and the pastures have become bare. Dry spells in moderation are not without benefit; they certainly enforce a rest period for the soil; they bring about the destruction of much coarse vegetation either by compelling stock to eat it or by inducing bush fires to consume it; they sweeten the soil by favouring aeration through the cracks produced on the

surface, and they have a controlling influence on the many animal diseases and parasites. The visitation of severe and extensive periods of drought, however, always constitutes a grave menace to prosperity. The primary effect is to cause a serious depletion of the live stock population. The drought of 1902 reduced the number of sheep by nearly nineteen million, and that of 1914 by three and a half million. During last year Queensland was in the grip of a drought said to be the worst experienced in that State for over twenty years; it affected an area of about 200,000 square miles, and the losses in sheep alone amounted to some five millions. Loss of stock is only part of the burden drought throws upon the pastoralist. The productivity of the animals which survive becomes lowered and the natural increase of the flock is seriously checked. A heavy outlay of money is incurred in the removal of the flocks to more favoured districts, or in the purchase and carriage of fodder where hand-feeding is resorted to. Further expense is entailed in re-stocking the holding after the drought breaks. Innumerable incidental expenses have also to be met, and should the resources of the afflicted pastoralist be unable to withstand the strain, his holding must be forfeited. In addition to the losses that fall directly upon the pastoralist, there are those of the State to be taken into consideration, such as decreased revenue, diminished income tax, reduced earnings of railways, etc. Consequently each severe drought causes a condition of financial stringency which interferes to a greater or less extent with all commercial and industrial activities. It has been estimated that the recent drought in Queensland was responsible for a loss of about £12,000,000 to that State. Each State suffers a similar experience from time to time; sometimes two or more become affected concurrently. If the losses directly traceable to the droughts that have occurred in Australia could be computed, the

aggregate sum would be colossal. Control of the effects of drought is therefore a national matter, and to the sheep industry it is regarded by many as being of paramount importance.

The control of the effects of drought is in fact a complex problem owing to the varying conditions that prevail, not only in different States but in the different districts of each State; measures of primary importance in one area often become quite subordinate in another. A review of past experience with droughts indicates that the losses decrease somewhat as settlement advances and local knowledge accumulates. Progress, however, has been slow and costly, and much time and money can be saved by more enterprise in developing the following safeguards:

Fodder Production and Conservation.—Notwithstanding the numerous droughts our pastoralists have experienced and the enormous losses they have suffered, each recurring prolonged dry period still finds many unprepared to carry their stock over the lean months. The uncertainty of the occurrence of drought, the fickleness of its intensity, and the indefiniteness of its duration undoubtedly induce some pastoralists to take a risk and rely upon making up the losses during good years—a practice that is apt to end in disaster. Bare pastures and dying animals invariably lead to a revival of agitation for some national scheme for fodder conservation to assure at a reasonable cost an adequate supply for starving stock. Many schemes have been advanced, and the one which appears to have found most favour in New South Wales is that proposed by a Special Committee of representatives of the Government, the Chamber of Commerce, pastoralists, bankers and the meat industry, under which the necessary funds are to be provided by the State issuing interest-bearing bonds to farmers and stock-owners, as well as to ordinary investors.

To insure success, a Board representing all intérests directly concerned is to fix, from time to time, the purchase and sale prices of the fodder and to control storage and distribution. Based upon the fact that adequate supplies of fodder can be grown by farmers, provided at least some of the cost of production is recoverable and a profitable market ultimately assured, a less comprehensive scheme has also been suggested to make fodder conserved in an approved manner on selected farms, a tangible asset upon which banking institutions might advance portion of the cost of production, or grant the ruling rate of interest on cost, during the period it is held in good condition, subject to the right of calling it up for sale at a reasonable price when required for distribution. A third scheme suggested is the establishment of an insurance fund, to which all stock-owners will contribute an annual sum based largely upon the nature, character and location of their holdings, to secure when required a supply of fodder at fixed prices from reserves built up by judicious purchase. It is obvious, however, that any complete scheme for national conservation of fodder will require a big financial backing, and while several Governments have given the matter much consideration, none so far has taken definite action towards providing the requisite funds. The view has been expressed that the large amount of public money that would be required to finance any national scheme might be spent to better advantage in extending existing railway systems and improving the main roads: in this way not only will the transportation of stock and fodder during drought periods be facilitated, but further development of pastoral areas will be materially advanced. It is equally evident that until some national scheme of fodder conservation is put into operation stock-owners must fend for themselves, and provide their own fodder reserves.

In areas suitable for mixed-farming, or where the soil is fertile and a rainfall of at least 20 inches per annum is usual, the cultivation of fodder crops at least sufficient for home consumption should be regarded by sheep-owners as an essential part of their business. For years the Department of Agriculture in each State has been encouraging this class of sheep-farmer to grow fodder crops, not only to supplement the natural food supply, but as an assurance against drought. The efforts of the Department have been supported by the activities of various organisations such as the Agricultural Societies and Bureaux, and much useful information has been disseminated as to which crops to grow, when and how they should be sown, cultivated and conserved. In addition to growing special crops for fodder conservation, farmers can convert the rank growth of their cultivation paddocks into silage with considerable profit to themselves. The advantages of conserving fodder in silo pits have been abundantly demonstrated, and the great value of silage for sheep, and more particularly lambing ewes, is becoming generally recognised. Improvement of the pasture lands by the application of artificial fertilisers and introduction of better grasses, clovers, etc., not only increases their carrying capacity but makes them tolerant to dry seasons. The striking success that has attended the creation of new varieties of drought-resisting wheat and the elaboration of new methods of farming, particularly in dry areas, clearly indicates the influence the development of agriculture must have on the welfare of the pastoral industry. In the past, effort has been somewhat concentrated on the production of wheat, but each year sees more attention being given to the improvement of other crops. An extensive field in the introduction and cultivation of new varieties of plants and cereals suitable as fodder exists, and is gradually being exploited.

For instance, the best has not yet been obtained from lucerne cultivation, nor has most been made of the cotton bush crops, the decorticated seeds of which are useful as concentrates. Consequently it would appear that, in areas capable of agricultural development, the present difficulties of assuring fodder supply during drought periods will progressively diminish.

The position, however, is different with the holders of big sheep runs who are gradually being driven into the drier areas, inasmuch as they have to provide for large numbers of sheep, often running into many thousands, grazing on land unsuitable on the whole for agriculture. With them a prolonged drought is always a serious matter, but the resultant losses are dependent on many factors, such as the nature of the holding, amount of average rainfall, extent of improvements, efficiency of management, accessibility to railway, etc. It may be accepted that pastoralists on the whole are not opposed to the principle of fodder conservation. A few who can afford to do so endeavour to build up reserves by purchasing hay and maize when the market price is low, and storing them at convenient sites. On a few big pastoral holdings an effort is made to grow some fodder crop on alluvial patches that can be irrigated, but the amount conserved rarely exceeds that required for preserving the stud sheep. On others, not so favourably placed, an attempt at cultivation is sometimes made on a small scale, and usually two out of every three crops sown give a return that proves helpful. Also the conservation during good seasons of natural grasses and herbage as hay and silage, is occasionally carried out. While considerable benefit has been derived from the treatment of specially selected paddocks, the extensive application of artificial fertilisers to the soil on these big pastoral holdings is not considered practicable.

The general feeling among the big pastoralists appears to be that it is either impracticable or unprofitable to conserve enough fodder to feed their large numbers of stock during long periods of drought; impracticable because of the difficulty in obtaining the necessary labour in these remote parts just when it is required, and unprofitable because of the large amount of capital that would be locked up for an indefinite period in an asset that often depreciates in value.

The problem of acquiring fodder reserves for big pastoral holdings is obviously one of an economic nature, but it is equally obvious that the extent of the reserve necessary for the majority has a direct relationship to the manner in which the natural sources of fodder have been conserved by efficient management, subdivision of the holding and distribution of water supply. In the semi-central pastoral zone, where the holdings are extensive, the heat great and the rainfall scanty, the carrying capacity is usually low, running from a sheep to ten to twenty acres or more, and the stock subsist largely on various low-growing shrubs and trees that have acquired a marked resistance to drought by morphological adaptation. Under occupation much of this natural source of fodder supply has become depleted, and as quite a lot of this class of country is suitable for wool-production, special effort must be directed towards the regeneration of the best of the native vegetation, and the augmentation of the natural supply by cultivation of drought-resisting grasses, fodder shrubs and trees. Of considerable value, therefore, are the investigations being made at Koonamore (north-east of South Australia, 8-inch rainfall) upon an area of eaten-out salt-bush 1,000 acres in extent, which has been given to the University of Adelaide as a vegetation reserve for research work. These investigations are being carried out under

the supervision of Professor T. G. B. Osborn, with the object of studying natural regeneration when all grazing influences, including those of rabbits, are removed. They are also designed to study the ecology of the area and particularly the autecology of species most valuable economically. Later on, it is proposed to ascertain the effects of grazing of known intensity on the process of regeneration. This work has been in progress for over a year, and arrangements have been made for the active co-operation of the Council for Scientific and Industrial Research. Its extension into other arid districts is under consideration by the Council, and pastoralists can well assist by making areas available. A considerable amount of information has already been collected by various botanists and agrostologists as to the nature and habits of most of the drought-resisting vegetation which experience has shown to be serviceable for feeding stock. Some ten years ago a scheme was launched in New South Wales for the encouragement of land-holders to plant and cultivate indigenous fodder trees. A forestry nursery was established at Dubbo for the supply of seedlings, and in 1923 nearly 25,000 were distributed to farmers and graziers, together with instructions as to their cultivation. It is therefore evident that with development along these lines the problem of fodder conservation for even the large holdings in the purely pastoral zone must also gradually diminish in intensity.

Water Supply and Conservation.—The early occupation of pastoral country was determined by the evident natural supplies of water, and as settlement gradually extended from these favoured areas, water supply and conservation became one of the most important problems of the pastoral industry. Individual settlers endeavoured to overcome their own difficulties, but the toll of ever-recurring drought, and the necessity of assuring a satisfactory supply to encourage the occupation of vast areas of fertile

land devoid of permanent surface water, compelled the various Governments to establish special services to acquire permanent supplies of water for stock, agricultural and domestic purposes. The work carried out by these services is important and extensive.

Of the big schemes for water conservation, the following must be mentioned:—In New South Wales, the construction of the Burrinjuck Dam at a capital expenditure of about twelve million pounds, to supply the Murrumbidgee Irrigation Area for growing crops, and to assure water supply to the lower river during drought periods; the construction of the Hume Dam, that has cost some nine millions, shared equally by the Commonwealth and States of New South Wales, Victoria and South Australia; and the provision of a storage at Lake Victoria (N.S.W.) for the use of the South Australian river settlements during periods when the natural flow of the River Murray requires to be supplemented. In Victoria, the artesian supply having proved not as serviceable as that of the northern States, extensive schemes have been carried out with great skill to provide water for domestic and stock purposes, the capital expenditure on which at 30th June, 1926, was £7,276,000, the area of land artificially supplied with water being 22,500 square miles. The principal one is the Wimmera-Mallee system, which is said to compare favourably with any similar undertaking in the world. Others, also regarded as comprehensive, have been carried out, or are being contemplated. Queensland also has under consideration national work in irrigation, the most important being the Dawson Valley Scheme. The Goldfields Water Supply, of which Western Australia is justly proud, has supplied permanent water for stock in districts adjacent to the line of pipes leading from the Mundaring Reservoir to the eastern goldfields.

Having completed the scheme for supplying water for domestic and stock purposes to an area of a million acres in Western Riverina, the Water Conservation and Irrigation Commission (N.S.W.) is now engaged upon the Gunbar extension to serve half a million acres north of the Murrumbidgee, from the vicinity of Griffith out to Booligal. The Commission has also a number of other projects under consideration, in connection with the Lachlan, Macquarie, Namoi and Peel Rivers. Of these, special mention might be made of the proposal to construct the Wyangala Dam across the Lachlan River, which has been recommended by the Parliamentary Standing Committee, on condition that the vast area of Crown lands, over 800,000 acres in extent, between Euabolong and Roto, is made available for closer settlement. This scheme aims at settling some five hundred farmers by supplying domestic and stock water by a network of channels similar to the system so successfully adopted in Victoria.

In addition to these national undertakings, much has been accomplished by private enterprise, and on many holdings large sums of money have been spent in impounding water by the erection of dams across water-courses, and the construction of tanks to catch the "run off" from the plains. On highly improved holdings these reservoirs are numerous and the water is well distributed over the run by means of mechanical power and pipes, or by gravitation and open drains, to reduce the distance stock have to travel when they wish to drink. Travelling long distances to water not only lowers production, but during drought it leads to rapid exhaustion. Where permanent provision has not been made or the supply has dried up, motor tractors for transportation of tanks filled with water are used with much advantage. Fencing the reservoir off

and conveying the water by mechanical means to troughs from which the stock drink has been found to be a much safer and more economical method than allowing the stock to have free access to the reservoir itself. It is also becoming recognised that the loss from evaporation can be materially lessened by increasing the depth of the tank and growing trees near-by.

The discovery of the artesian water supply, and the subsequent exploitation of the seven artesian basins, has made possible the profitable occupation of large areas of land for pastoral purposes. The return for year 1925-6 gives the number of existing artesian and sub-artesian bores as follows:—New South Wales 518, Victoria 367, Queensland 3,138, South Australia 144, Western Australia 230, and the Northern Territory 180, making a total of 4,577, yielding a daily flow of 459,594,000 gallons.[10] While the great majority of bores have been sunk and paid for by the occupier, considerable assistance has been given by the Crown.[11] In New South Wales, at the end of 1926, seventy-one trust districts had received assistance to serve an area of 4,354,545 acres with 2,803 miles of drains for stock watering purposes, and, in addition, twelve artesian well districts embracing an area of 324,947 acres had been helped. The total expenditure by the State on these trust and artesian well districts had amounted to about £239,000. The Water Conservation and Irrigation Commission, besides having two deep well plants sinking bores in trust areas, has thirty-five plants at work in shallow-boring in three districts, for settlers of moderate means, and up to 30th June, 1926, 1503 effective bores had been sunk, and many more have been applied for. Pastoral Queensland is largely served by the Great Australian Artesian Basin, the estimated yield of water from 1,362 flowing bores on 30th June, 1926, being 291,621,910 gallons per

diem. On that date fifty-two bore water supply areas were completed, comprising a total of 4,696,924 acres, over which water was distributed in 1,939 miles of drains. Five additional areas are in hand, including a further 611,791 acres, and 361 miles of drains. A series of bores has been sunk in dry areas of South Australia for watering stock, and the yield from the flowing bores at 30th June, 1926, was 12,973,000 gallons per diem. In Western Australia the number of Government bores is almost equal to that of private bores.

From the above it will be seen that considerable progress has been made in solving the problem of water supply and conservation, and that while much has been accomplished by private enterprise, comprehensive and costly undertakings have been carried out by the Governments. The extent of these undertakings in the eastern States at least, is probably much greater than is generally realised.

While much of the artesian and sub-artesian water is quite serviceable for both domestic and stock purposes, some of it, unfortunately, is so highly charged with mineral salts that it is unsuitable even for the use of stock. The chief salts are those of sodium, calcium, magnesium and potassium, existing as chlorides, sulphates, or carbonates. Silica is sometimes present, and occasionally traces of iron and aluminium are found. The standards for safe water adopted in the different States vary; apparently in each case it has been adopted independently, as the result of the experience of the official chemist. For example, the extreme limit of total dissolved salts which will not injuriously affect sheep, in grains per gallon, is regarded in Queensland and Victoria as 600, in New South Wales as 1,350, in South Australia as 875, and in Western Australia as 900. It is possible that a number of factors

has operated in the determination of these different standards. At the Perth Meeting of the Australasian Association for the Advancement of Science (1926), the standardisation of methods for water analysis was urged by both Dr. E. S. Simpson (W.A.) and also Mr. R. Lockhart Jack (S.A.). As the different mineral salts of water vary considerably in amount, and as it is recognised that interaction influences toxic effect, Mr. R. Lockhart Jack further suggested, in the hope of getting a more comparable basis for analysis, consideration of assigning factors to the various "assumed salts," to reduce them to their equivalent toxicity expressed as common salt instead of for the precisely determined ions and radicles. Of the various mineral salts, sodium chloride is common, and is usually regarded as the most harmful, partly on account of its known toxicity in excessive doses, and partly on account of its association with "brackishness." It is recorded, however, that sheep have lived for several weeks during the summer months on water containing as much as three ounces of salt per gallon, when they were watered at sundown from freshly filled troughs. Management is therefore an important factor, but the nature of the food and the distance the sheep travel to water, also have their influence. More definite knowledge as to the tolerance of sheep and other stock to the different mineral ingredients of bore water, both separately and in association, is undoubtedly very desirable, and the investigations now being carried out by a special Committee appointed by the Australian National Research Council are bound to lead to a better understanding in the usage of bore water, and thus confer much benefit upon the sheep industry.

It will be seen from what has been stated that much has been done by both State and private effort to overcome the problem of Water Supply and Conservation.

With extensive areas made safer for stock occupation and thousands of acres made available for mixed-farming, considerable expansion of the sheep industry must take place.

Weather Forecasting.—Not only are droughts irregular in their occurrence and duration, but they are often terminated by heavy rains resulting in extensive floods that cause much loss of live-stock and property. The disastrous results of droughts and floods could be considerably reduced if it were possible to give sufficient warning of their advent. While our meteorologists are becoming increasingly accurate in forecasting weather conditions up to 36 hours, their prophecies usually decrease in reliability as this period is exceeded. In India, owing to its peculiar geophysical characters, advance has been made in long-range prediction, but it is unlikely that much progress will be evident in Australia until many additions are made to our scientific knowledge. No doubt, the publication of accurate weather records by important countries in different parts of the world will prove helpful, but it would appear that any material progress must depend upon long and intricate research. Of recent years the work carried out by the Observatories of the Smithsonian Institution (U.S.A.) in connection with solar radiation has attracted much attention, and it is interesting to note that Clayton, of the Argentine Meteorological Service (S.A.) by the correlation of weather changes with changes in solar radiation, has been enabled to extend the period of weather forecasting to seven days with, it is reported, satisfactory results. Should this aid be successfully applied in other centres, a great impetus will be given to the study of solar radiation in Australia, which will be very gratifying to at least one member of our Council (the Rev. E. F. Pigot) who for some years has

been carrying out, under great difficulties, research in this subject at the Riverview College Observatory, Sydney. While many scientific fields may be exploited with advantage in weather forecasting, solar radiation seems to be the one that offers the most fruitful results. The establishment of meteorological stations in Antarctica no doubt will be useful, and it is urged that even if the prospects of "long-range" forecasting in Australia are regarded as remote, the development of a "longer range" than the present methods provide will be of distinct service to our pastoralists and farmers.

Facilities for Transportation.—As droughts vary in range and intensity, it often happens that while the pastures in some districts are bare, those in others provide abundantly for the stock. Consequently many pastoralists, whose holdings are not too far removed from a railway service, find it more economic to send their stock from the drought-stricken area to favoured districts, than to build up large fodder reserves. The usual practice is to relieve the holding by removing the flock sheep and to hand-feed those reserved for stud purposes. Our railways consequently play an important part during drought periods in transporting starving stock and carrying supplies of fodder. In this way they also prevent the excessive depletion of pastures which results from continued occupation during dry times. Practically all our railways are state-owned, and it is usual for Governments to grant freight concessions to help stock-owners over their difficulties. While acknowledging the great value of the present services, it must be recognised that still greater relief can be afforded not only by extending into new territory, but by looping up the radii and linking up the termini of the numerous branches already constructed.

An outstanding need for pastoralists of eastern Australia, and one that has been advocated for many years not alone by graziers, but by Railway Chiefs and Officers of the Defence Department, and also strongly supported by Professor Griffith Taylor, is the linking up of the termini of the railway systems that radiate from the centres on the east coast. It has been asserted that the cost of construction of the lengthy portion that is to connect Camooweal (Qld.) to Bourke (N.S.W.) would have been largely repaid by the saving in live stock effected during the recent drought. As this particular construction interests more than one State, the assistance of the Federal Government has been invited, and it is understood that the matter is receiving favourable consideration.

Where railway service is at present remote, stock routes and ordinary roads must continue to serve transportation requirements. Over both of these some control is now exercised, but much room exists for improvement. Stock routes must be reasonably extensive, adequately watered and kept in good condition, or they fail when most needed; and roads serviceable at least under ordinary conditions are essential for the development of the far-off inland areas.

Improved Animal Nutrition.

All observant stock-owners know that if animals do not receive sufficient nourishment, their growth becomes retarded, their productivity diminished and their fertility lessened. Also that animals in low condition are more liable to disease and parasitic infestation. Sufficient nourishment, however, does not merely mean plenty to eat, and it often happens that the food supply, while ample in bulk, is sadly deficient in one or more ingredients essential for the physiological requirements of the animal.

When Lavoisier in 1780 applied the balance and thermometer to investigations of the phenomena of life, the foundation was laid to the scientific study of the problems of nutrition. For over a century and a half these problems have engaged the attention of many bio-chemists and other scientists to whom we fully acknowledge our great indebtedness. The early researches were concerned mainly with the welfare of man, but as animals are usually kept for profit, their owners naturally desired to know in addition to the physiological requirements, the relationship between the cost and the feeding value of the various food-stuffs. In this connection Germany gave a valuable lead in 1864 when Dr. Emil von Wolff presented in Mentzel and von Lengerke's Agricultural Calendar for that year, the first table of feeding standards based on the digestible nutriments contained in food-stuffs. The Wolff feeding standards were subsequently published annually down to 1896. From 1897 to 1906 they were presented by Dr. C. Lehmann, with some modifications, but in 1907 Dr. D. Kellner took charge and made an important advance by substituting tables and feeding standards based on the Starch Equivalent values determined by careful experimental work, and by recognising the requirements for production over and above those necessary for maintenance. As the importance and economic value of standardising food-stuffs became recognised, other countries gave attention to the subject, more particularly perhaps, the United Kingdom, the United States of America and Canada. As a result many experimental stations have been established and well-endowed to work out the feeding value of available food-stuffs and to disseminate by popular bulletins the knowledge gained, much to the advantage of stock-owners.

Notwithstanding its importance to our greatest primary industry, Australia has certainly lagged behind in this branch of research, not so much from want of appreciation, for in the curricula of our veterinary schools the principles and practice of scientific dietetics have always had a prominent place, and the urgent necessity for provision to carry out investigations in Australia has been stressed on many occasions. Our chemists, especially Brünnich (Qld.) and Guthrie (N.S.W.) have made a considerable number of analyses of Australian fodder crops, cereals, grasses and shrubs, and a certain amount of work has been done by the few bio-chemists we possess, but the progress made by this individual effort has been slow, and the results obtained are small when compared with those accomplished by the well-endowed and efficiently staffed institutes of other countries.

In the tables giving the composition of various foodstuffs, the percentages of digestible crude protein, carbohydrates and fat for tissue and energy supply are given, together with that of ash, and the nutritive ratios are stated to indicate dietary values; but rations based on this data alone often give a diet deficient in mineral matter and vitamines, the dietary of importance of which recent research in bio-chemistry and pathology has amply demonstrated. In both man and animals a condition of depraved or perverted appetite known as Pica has long been recognised. Pica is always a sign of disturbed or deficient nutrition, and is more common when great demands are made on the animal's system, as in the growing period and during pregnancy and lactation. One manifestation of this condition is earth-eating (geophagia); under natural conditions animals are known instinctively to seek localities where the surface soil is impregnated with mineral matter, and to establish "lick holes." In advanced

cases affected animals eat faeces (coprophagia) and the dried bones of dead animals (osteophagia); both these materials contain calcium and phosphorus. Osteophagia leads to other diseases which further lower production, and some may cause death. The most serious complication in cattle is a form of "Botulism."[13 & 14] Theiler's investigations in South Africa showed that during the periods osteophagia becomes prevalent—namely in the autumn and winter and in dry seasons—the native grasses are deficient in phosphorus, the ratio of starch equivalent to P_2O_5 decreasing from 100 to 1.07 to 100 to 0.36, and further that osteophagia could be controlled by supplementing the deficient vegetation either directly through the mouth by feeding various phosphorus-containing compounds, or indirectly by applying phosphatic manures to the pastures.

In Australia Pica is not uncommon in all classes of stock. In some areas, particularly coastal districts, it is enzootic, frequently associated with osteophagia and osteomalacia, the latter being well seen in cattle and horses. It may become manifest in sheep during dry seasons, when the nutritive value of the pastures diminishes. Guided by the results obtained by Theiler in South Africa, bone meal has been administered with good results, but bone meal contains calcium and other mineral ingredients as well as phosphorus, and apart from the benefits that may be derived from an additional allowance of calcium when the pastures are deficient in its salts, it has been found that a balance consumption of lime leads to a better retention of the phosphorus.[15] Calcium and phosphorus are but two of the number of mineral ingredients vegetation derives from the soil, and a shortage of any may lead to mineral deficiency. In the North Island of New Zealand the cattle suffer what is known as "Bush sickness"[16], the cause of which is ascribed to a shortage

of iron, and the administration of citrate of ammonia and iron has been attended by marked beneficial results. Recent investigations in the mineral requirements of growing animals make it increasingly evident that the adjustment of the proportions of the inorganic constituents of a ration requires as much consideration as the absolute amounts of these elements in the diet. Even though a mineral is present in a ration in sufficient amount for the animal's requirement, the presence of other minerals in unsuitable proportions may lead to insufficient assimilation and retention. The inter-dependence of the different mineral elements is of importance; some, in proper proportions, will increase the assimilation of associated mineral matter; others, given in excessive amounts, will exert a depressing effect. As Orr points out,[17] if the ration already contains sufficient of any mineral, the addition of that mineral can do no good, and indeed, may do harm. The surplus supply not only lowers the dietetic value of other ingredients, but the additional strain thrown upon the excretory organs may cause disease. This aspect of mineral nutrition is of considerable importance to our sheep-owners, owing to the tendency of recent years, especially during drought periods, to supplement the natural food by an allowance of mineral in the form of licks, without any exact knowledge of the nature of the deficiency, which must of necessity differ in districts of varying geological formation and rainfall.

The big sheep of to-day not only require more nourishment for maintenance than formerly, but the heavy fleeces they now carry demand still more for production. To grow wool of uniform quality, sufficient nourishment must be continuously provided. While our best pastures so far have retained their high nutritive value, there is

evidence that others are decreasing in carrying capacity, especially during dry spells. Many factors have operated in lowering the nutritive value of pastures, and both remedial and preventive methods must be devised, but obviously much research will be necessary before the exact deficiencies can be properly dealt with. To be complete, it must include extensive soil and botanical surveys, ecological study of our vegetation, chemical examination of grasses, herbage, edible shrubs and trees, together with experimental feeding to determine nutritive values for both growth and production in different seasons. It is in this way that animal nutrition problems have been tackled successfully in other parts of the world.

In the past we have been guided largely by investigations carried out in other countries, and the time is long overdue for us to endeavour to work out our own problems under our own conditions. This fact, together with the extensive field that exists, led the Council for Scientific and Industrial Research, soon after its establishment, to take the matter up. As a first step, a special Committee consisting of bio-chemists and veterinary scientists was appointed to report on the position, and it is satisfactory to know that arrangements have now been made for an extensive and fundamental investigation into problems associated with nutrition of stock in Australia.[18] Work is being carried out by the Council in co-operation with the University of Adelaide, and the Waite Agricultural Research Institute (S.A.). To commence with, the applied work will be limited mainly to sheep, considered as meat and wool producers, the investigations having been planned in two main divisions. Arrangements have been made for a fundamental investigation of the nutrition of animals, to be carried out under the control of Professor T. Brailsford Robertson, with the primary object of ascer-

taining the exact nature of certain deficiencies in leaf protein of those fodder plants upon which Australian sheep chiefly depend in times of drought. Afterwards, the investigations will be extended to other plants, especially those which make their appearance after rain in arid regions, and finally to the pasture plants in the districts that have more abundant rainfall. Investigations with laboratory animals will also be carried out in order to determine the effects of excess magnesium or potash upon the mineral equipment of the animal in other directions. The iodine content is also to be dealt with. Later on the fundamental work will be linked up with field investigations on sheep.

Further, with a view to extending investigations in the problem of mineral deficiencies of pastures, the Empire Marketing Board has made funds available on a contributory basis for research to be carried out in Australia. The offer was originally made to Professor A. C. V. Richardson, Director of the Waite Institute (S.A.) and has now been transferred to the Council. The general object of the work is to determine the role of mineral nutrients on growth, development and nutrition of stock. Special attention will be devoted to the effect of deficiencies of phosphorus and calcium on pastures.

There can be no question as to the wisdom of the Council in undertaking this work. The problems are very complex, and as research is usually a slow process, spectacular results are not anticipated. The field, however, is so extensive as to give rise to some misgivings as to whether the central organisation will be able to yield the best results within reasonable time, unless its work is supplemented by State effort. In each of the States some scientific organisation already exists that is capable of rendering valuable aid in developing and applying the scheme

of work, and the special training at headquarters of selected workers from the different States, in approved methods of investigation, would undoubtedly expedite results. Some such arrangement to assure extension of the field of inquiry and correlation of results, will most probably be considered by the Council in due course, and it is of particular interest to note that the Council has invited Dr. J. B. Orr, Director of Research in Animal Nutrition at the Rowett Research Institute of Aberdeen, Scotland, Sir Arnold Theiler, Director-designate of the Bureau of Animal Health, London, and late Director of Veterinary Education and Research, South Africa, and Sir John Russell, late Director-designate of Soil Science Bureau, London, to visit Australia, and after studying local conditions, to advise on the future development of research here. A further benefit from the visit of these eminent scientists will be the active co-operation between British and Australian investigators in the study of animal nutrition and soil problems—a development that is receiving encouragement from the Imperial Bureau (U.K.).

These projects will no doubt bring about a better understanding in the scientific feeding of animals in Australia, and much beneficial guidance will be given our stock-owners as to the nutritive value of both natural vegetation and supplementary sources of food supply. As a result our stock will grow better, produce more, and multiply satisfactorily.

Wool Production.

From historical records, it is gathered that the sheep first brought to Australia were of either the coarse-wool type or the hair-bearing variety. Of the early coarse-wool sheep introduced, one lot brought from Ireland, and sub-

sequently known as the "Irish Breed" evidently played an important part, as the improvement in the fleece of an offspring of a hair-bearing Bengal ewe got by one of the rams drew the attention of McArthur to the prospects of growing wool in Australia. From the evidence available,[19] this so-called "Irish Breed" seems to have been the ancient Northumberland or Teeswater breed now known as the Wensleydale.

The introduction of the Spanish Merino in 1797 is generally regarded as initiating the fine wool industry of Australia. The term "Spanish Merino," however, is a general one, as in the course of several centuries many types of Merino have been evolved in the different provinces of Spain. It has been surmised that the Merinos imported from South Africa in 1797 were the Escurial type, while those that came from the flocks of King George III in 1804 were the Negrette type. Other types have been evolved also in several countries into which the Spanish Merino has been introduced, such as the Rambouillet (France), Saxon, Silesia, Gadegast and Steiger (Germany), Vermont and Delaine (U.S.A.), etc. Of these, our sheep breeders imported those regarded as most serviceable, so that it may be claimed that in addition to the original Spanish types that came from South Africa and England, the best of the world's fine wool producing sheep have been used in building up our present flocks. Consequently, although one refers in general terms to the pure Merino of Australia, it must be recognised that actually our flocks contain many strains of the different types of Merino. Individual flocks, by selective breeding for many years, have acquired definite characters, so that a number of sub-types has been evolved in Australia in which one or more of the imported strains at least pre-

dominate. For instance, the famous Wanganella sub-type was founded by using Rambouillet rams, especially one called Emperor, of the Paular strain, noted for size and plainness of body, brought from France in 1862. The creation of further sub-types must proceed to adapt our sheep to the wide range of environmental influences that obtain in Australia, and while not detracting in any way from the merits of our leading breeders, the opinion is advanced that very material assistance can be given to their efforts by the application of more scientific methods.

It is true our breeders have increased the quantity of wool grown per sheep in a striking manner. In 1827[20] the weight of fleece from cross-bred ewes and wethers averaged 3 lbs., that of pure-bred Merino 2 to 2½ lbs., and that of the ewes seldom exceeded 1½ lbs.; while in 1927 the clip in New South Wales averaged 8.8 lbs. per sheep and the fleece of individual stud rams weighed over 40 lbs. This has been done by individual effort, but it has taken just one hundred years to accomplish it!

With this remarkable increase in the weight of fleece, the size of the sheep has gradually become greater, but the fineness of wool is not so marked as formerly. While the present type of sheep is the most profitable under existing market conditions, it is difficult to say how long the demand for strong wool will remain at the current high level. The market is always largely influenced by fashion, and as the textile manufacturers have to cater for the prevailing fashion, the tendency of the day is to establish a closer co-operation between the wool grower and the woollen textile manufacturer. It is of interest to note that the textile industry has generously founded a department at the University of Leeds to investigate its problems, and much scientific research is now being carried out

there that must have an important bearing on wool-growing in Australia. Unless research is carried out on similar lines in Australia to correlate results our position will indeed be invidious. That a wide and extensive field exists here is patent to all who have given the matter serious consideration. "Bawra" classified the Australian wool production into 848 distinct types.[21]

The benefits to be derived by the application of more scientific methods are many. The most generally recognised indications of wool value are fineness, length, density, strength, crimp, lustre, stretch, shrinkage, and uniformity, all of which are capable of definite measurement, except lustre, which fortunately is fairly evident to the sight. It is known that environmental influences do affect many of these characteristics; a breed of sheep producing fine wool under certain conditions may produce strong or medium wool under other conditions, and *vice versa.* Exactly which hereditary factors of our different types favour or retard the change-over have not been determined, but the solution offers a fruitful field for investigation. Hitherto sheep classers and wool buyers have relied upon digital manipulation and the unaided eye in judging the character of the wool, and the expertness many have attained by long experience aided by natural aptitude is truly remarkable. But with this practice, the value of the judgment made always varies to some degree with the proficiency of the judge, and disagreement in estimation is not uncommon. Of recent years the requirements of the textile trade have necessitated the standardisation of essential properties of wool, and as a result, scientific apparatus and methods have been elaborated to give a more accurate estimation. Fineness of wool is one of the chief factors in determining its value, but as wool fibres vary in diameter from about 1/300th

to 1/2000th of an inch, the necessity for accurate means of measurement is apparent. Several methods are now in use, of which the micro-metrical method combined with "frequency distribution curve" appears to be most favoured at the University of Leeds. The wool is examined microscopically and the diameter of the individual fibres read off by the aid of a micro-meter eye-piece with divisions of 1/10,500th of an inch. From the measurements made (over one hundred) the average diameter is obtained, and by grouping the measurements according to units of space and plotting the results the "frequency curve" is obtained which gives very definite information. From this and other data equally accurately determined, statistical methods of investigation may be carried out, and the true nature of the wool revealed, and its commercial value determined. So much progress has been made in this connection that it can be safely said that a student, by the use of scientific apparatus and the application of statistical methods, can in a few weeks determine and value the characteristics of wool with at least the same degree of accuracy as that possessed by ordinary wool-classers with years of experience behind them.

Further, to the breeder uniformity in fleece is of paramount importance, and it is usually judged by examination made by sight and digital manipulation of the wool growing on different parts of the sheep's body. Many breeders have acquired remarkable proficiency in judgment after years of close application; others who lack natural aptitude find difficulty in becoming proficient, even after years of experience. An apparatus now exists that can be used with advantage by all, as it quickly reveals the degree of fineness of the individual fibres in any sample, and clearly shows up variations. Last year Dr. Henseler, Director of

the Institute for Animal Breeding and Biology of the Technical High School, Munich (Germany), demonstrated the value of his apparatus at the Veterinary School of the University of Sydney. The apparatus is of the nature of a projection lantern, the magnified wool fibres or hair being thrown on to a screen, furnished with millimetre division squares, from which critical examination is made. It was stated that the apparatus has proved of great assistance on the Continent of Europe in the purchase of rams for flock improvement, and various agricultural organisations are using it with much benefit to their sheep breeders. There is scope for similar assistance to be given to our small sheep breeders, to shorten the road to success.

Enough has been stated to indicate the value of the application of scientific methods for the reliable analysis of wool. Of greater importance still are the benefits to be derived by the application of more scientific methods in the breeding of sheep. Many countries are alive to this fact and have not hesitated to seek the assistance of science to increase production. The Peruvian Government, for instance, has enlisted the services of scientists to improve its native flocks and an experimental breeding farm has been established at Chinquibambilla. Judging from reports to hand, the appeal to science has not been in vain, the fleece of experimental native sheep having been increased and improved by better methods of breeding. During 1926 Professor Alfred F. Barker, of Leeds University, was invited by the President to visit Peru and report upon the prospects of developing some 30,000,000 acres of wool-producing country.

It is very remarkable that in Australia organised study of the Animal Genetics is yet to be provided for. In my presidential address to the Veterinary Science section of the Australasian Association for the Advancement of Science

(1926), the necessity for making requisite provision was stressed, and in the post-scriptum of his Peruvian report[22] Professor Barker states "that it has been a disheartening experience to find that, notwithstanding the direct encouragement which the Universities of Edinburgh and Leeds have given to Australia, for example, so far no work of this type has found an accredited place in the Australian Universities; neither has there been in evidence, so far, that reciprocity and collaboration with the Home Universities which might lead to results industrially important and scientifically inspiring." Also that "sheep-breeding and wool-growing present fields for research in Genetics and Heredity second to no other fields, and as such should come within the activities of every University, and especially within the work of those Universities which are situated in the great wool-growing countries of the world."

These views need no endorsement, and it is hoped that before long proper provision will be made in Australia for research in wool production.

Control of Pests.

Numerous pests retard the development of the industry. Reference has already been made to the rabbit and dingo pests. In some areas noxious vegetation has taken possession of many acres of good pasture land, and occasionally large tracts of country are laid bare by the visitation of hosts of caterpillars. The greatest of all the insect pests sheep-owners have to contend with is the "blow-fly" pest, depredations of which have run into millions of pounds sterling.

The State Departments of Agriculture have not been inactive in combating these pests, and while progress has been made, the success that has attended efforts to eradicate

the prickly-pear and the woolly aphis by parasitisation has attracted attention to the possibility of dealing with other pests in a similar manner, thus obviating the labour and expense connected with present methods. The discovery and propagation of parasites to attack and destroy certain vegetable and animal pests entail much exacting scientific investigation by specially-trained workers. Economic entomologists of proved value are much sought after, and it is pleasing to be able to record that the Council of Science and Industry has succeeded in engaging the services of one so eminent as Dr. R. J. Tillyard, to co-ordinate the entomological efforts of the States and to elaborate new methods of attack. The parasitisation of the pupae of the blow-fly by the Chalcid wasp introduced by Froggatt has proved useful as a supplementary aid in controlling the propagation of this pest, and indicates the value more effective methods of biological attack may prove to the sheep industry.

THE CONTROL OF ANIMAL DISEASES.

The great majority of diseases affecting sheep in Australia have been introduced. Among the early importations disease other than Scab (Psoroptes communis var. ovis) was practically unknown, and as the hardships of transportation eliminated the weaklings, it may be taken that the survivors possessed a good constitution. Unfortunately, with subsequent importations, especially prior to the introduction of official supervision and quarantine regulations, many diseases and parasitic affections were brought to Australia. Of the grave affections that were rife during last century Malignant Catarrh and Scab have been eradicated, while Anthrax has been controlled by preventive inoculation discovered by Pasteur and elaborated by McGarvie Smith and Gunn, so that its

occurrence is now but enzootic. Other introduced diseases have become widespread, and they, together with a number peculiar to Australia, exact a very heavy annual toll from the sheep industry by decreasing production and restricting markets abroad. To prevent this serious leakage of revenue, the encouragement of Veterinary Science has become essential. Since the establishment of the first Veterinary College at Lyons, 1762, veterinary knowledge has gradually accumulated, but marked progress has been made in its development as a science during the past thirty years. The curricula of the teaching institutions clearly indicate the wide application Veterinary Science has at the present day, and as each year records material progress in our knowledge of animal diseases, the field is ever extending. Although Veterinary Science has not received in Australia the encouragement it enjoys in many other countries, a useful organisation is being built up gradually. At the present time two Veterinary Schools exist, the one in the University of Sydney and the other in the University of Melbourne, where complete courses of instruction and training are given, extending over at least four academic years. The graduates find many avenues for employment, but so far the majority have been absorbed in the veterinary services of the Federal Government or of the States. The Federal service supervises the importation of animals into Australia under the Quarantine Act, and the exportation of beef, mutton and lamb under the Commerce Act. It thus carries out important duties in safeguarding our flocks and herds from the introduction of further exotic disease, and in guaranteeing the wholesomeness of the meat produced to consumers abroad. The State veterinary services are usually attached to the Departments of Agriculture, and they vary in their degree of development. Considerable advancement has been made

during recent years in some, but the progress in others cannot be regarded as satisfactory. The best results only become possible when efficient field and research staffs act under capable administration. Advancement is most marked in the State of New South Wales, where the policy of appointing, as far as possible, qualified veterinarians as stock inspectors is proving very satisfactory, not only to the Department in providing highly-trained officers for the application of modern methods in the control of disease, but also to stock-owners, who derive much additional benefit from increased accessibility of advice and assistance in connection with breeding, feeding, etc. The value of the field officers, however, is largely dependent upon the investigations carried out by the research staff in the elucidation of the cause of disease, and in the elaboration of effective measures of control. In each State some provision exists for investigating animal diseases, ranging from the rudimentary scheme of Tasmania to the establishment of experimental stations and research institutes, of which that at Glenfield (N.S.W.) is the best example. Research in animal diseases is also carried out at both our Veterinary Schools. Much valuable work has been done, and the economic importance of some of it, such as the control of fluke infestation of sheep, has been greatly appreciated by stock-owners. Still, it cannot be claimed that the best results possible have been achieved, partly because in no instance has any one of the efforts had sufficient financial support for proper development, and partly because of the shortage in highly-trained research workers, owing to the limited facilities that exist for promising veterinary graduates to specialise in particular subjects. The only assistance so far given for the latter purpose is that of the Walter and Eliza Hall Trust in providing for two Veterinary Fellowships, and

the success attained by these Fellows clearly indicates the benefits that would be derived from pastoralists supplementing the generous action of this Trust. The absence of proper organisation of veterinary effort also has had its effect. At the present time each State is endeavouring to work out its own problems in its own way, a process that is often both tedious and expensive. Some scheme to assure effective co-operation between the different widely-separated activities, as well as to provide for intensification of effort in desirable directions, would go far towards expediting results. Consideration has already been given to this matter, and the Council for Scientific and Industrial Research is to be congratulated upon obtaining an organiser of Sir Arnold Theiler's ability to advise it as to future plans for developing research in animal diseases. The field is certainly extensive, and as many diseases of grave economic importance, such as Caseous Lymphadenitis and Braxy-like affections, prevail in more than one State, Federal guidance and assistance will no doubt be welcome.

Encouragement of Research.

During recent years there has been manifested in many countries a keen desire to enhance animal production by the application of more scientific methods, and many schemes have been put into operation. The 17th Annual Report of the British Development Commission[23] indicates the wide range of action being taken in Great Britain. The Commission is now working in close co-operation with Empire Marketing Board, and augmented funds have been made available to existing research institutes for investigations having an Imperial significance. During the last academic year (1926-7) some £140,000 was recommended by the Commission to encourage research in many directions, and among the institutes in the United Kingdom

that received assistance were the Animal Breeding Research Department, Edinburgh University; the Animal Nutrition Institute of Cambridge University; the Rowett Research Institute, Aberdeen University; the Institute of Animal Pathology, Cambridge University; and the Research Institute—Animal Pathology, Royal Veterinary College, London. Further, at the Imperial Agricultural Research Conference held in London last year, the establishment of a Bureau of Animal Nutrition at the Rowett Institute, a Bureau of Animal Health in London, and a correspondence centre for Animal Genetics at Edinburgh University, were recommended to facilitate interchange of information concerning recent investigations in these subjects. The correlation and linking up of work carried out under different conditions at the various centres throughout the Empire must prove a powerful stimulus to future effort, but in order to be fully effective it is essential that each part of the Empire must add its quota. While it cannot be said that Australia has pulled her full weight in the past, the prospects for better fulfilment of her obligations in the future appear encouraging.

From the frequent references to the activities of the Council for Scientific and Industrial Research, it is evident that the Federal Government is manifesting a keen desire to assist the sheep industry in overcoming its problems But they are only part of a great number of problems connected with primary industries as a whole which the Council has to consider, and it is questionable whether the funds placed at the disposal of the Council, originally regarded as ample, will be sufficient to meet the many demands. Consequently the action being taken by the wool-growers and wool-brokers to assist scientific research is very welcome. It is proposed to found a fund by voluntary subscription, on the basis of two shillings per bale of

wool during the present clip, and to use the interest accruing from investment of the capital in encouragement of research for the eradication of pests, the control of diseases, and the elucidation of nutrition and other problems. As an initial effort the objective of £200,000 aimed at is most praiseworthy, but as the interest on this sum will yield not much more than £10,000 per annum, it is clear that the capital sum will require to be considerably augmented before the full weight of scientific help can be applied. A further encouraging development is the additional proposal of the Pastures Protection Boards in New South Wales to devote £2,500 of their funds for five years in subsidising the Veterinary School at the University of Sydney, and the Veterinary Research Station at Glenfield, in order to encourage the development of Veterinary Science and to stimulate research in animal diseases. Each of these proposals is to be commended as a splendid example of an industry manifesting its willingness to provide means for the investigation of causes that retard its development, and as contributions to the funds will be largely influenced by the results obtained, it becomes incumbent upon the scientific institutions appealed to for aid to show a keen and active interest in the welfare of the greatest of our primary industries.

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THE CHEMISTRY OF WESTERN AUSTRALIAN SANDALWOOD OIL, PART I.

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Late in the year 1925 the author commenced an investigation into the chemistry of Western Australian Sandalwood oil with a view to identifying the alcoholic constituents of this well-known essential oil. Despite the fact that several chemists have already shown the alcohols to possess certain differences from the well-known East Indian oil, quite a number of writers still persist in definitely expressing the sesquiterpene alcohols present as santalol. (See H. V. Marr, Chemical Abstracts, Vol. 22 (1928), page 138.) The need, however, for the present investigation was made imperative by the divergent results published from time to time by various chemists, institutions, and manufacturers. Since Messrs. Schimmel & Co. (Annual Report, 1921 Edition, pages 39/41) and the Imperial Institute (Bulletin, Imp. Institute, 1920, 18, 163) examined the oil, the Western Australian manufacturers have made marked advances in the preparation for the market of an article containing not less than 90% sesquiterpene alcohol; in fact, almost invariably in the neighbourhood of 95-96%. The earlier results, therefore, are of negligible value at the present time as they were obtained upon samples containing only about 75-76% of sesqui-

terpene alcohols, and these were very much inferior to the excellent quality of oil now marketed. The production, however, of these high-grade oils does not necessarily mean that, even allowing for the chemical and physical constants being in agreement with the East Indian oil, that this Australian oil is identical in chemical composition, and I am able to show under "experimental" that such is not the case.

I am fully conversant with the fact that the Australian oil has been found to be equally efficacious and in some instances superior to the East Indian in pharmacology, but this investigation is concerned with its chemical composition.

The commercial oils were first examined on account of their economic importance, and also because the controversial articles appearing in the current literature refer only to this product. At the same time, convincing evidence has been obtained which shows that the elucidation of the composition of Western Australian Sandalwood oil will be accomplished only when specimens of wood from various parts of the trees occurring in the different localities of W.A. and carefully checked botanically are distilled, and the oils obtained therefrom carefully examined. Through the courtesy and assistance of Mr. S. L. Kessell, Conservator of Forests, Western Australia, who has evinced considerable interest in the problem and furnished the necessary supplies of material for examination, this work has been put in hand, but naturally some time must elapse before the investigation is brought to completion.

The object of this paper is to summarise the present state of knowledge regarding the chemistry of the commercial oil and the reasons for the divergent analyses published to date. The paper by Mr. Horace Finnemore

contributed to the Science Section of the British Pharmaceutical Conference, 27-31st July, 1925, (see "Perfumery and Essential Oil Record," August, 1925, page 254-256), summarised very succinctly the knowledge of the chemistry of Australian Sandalwood oil as at July, 1925. The further paper by Professor Emile Perrot entitled, "The Sandalwoods of Australia and their Essential Oils," published in the "Bulletin des Sciences Pharmacologiques," Nov. 1927, does not in my opinion show any distinct advance in knowledge of its chemistry over and above that given in Mr. Finnemore's paper.

It was found in the present investigation that the Western Australian oil reacted just as readily with phthalic anhydride in benzene solution on the water bath as the santalols of the East Indian oil, and appeared to be of a primary character, contrary to the experience of Messrs. Rao and Sudborough (Jour. Ind. Inst. of Science, 5, 1923, 163-176). This divergence may be explained by reason of the fact that Messrs. Rao and Sudborough made no reference to the presence of santalol in the oil examined by them (I have not had access to their original paper, my information being gathered from the abstracts), whereas the writer found these alcohols to be present to the extent of 40-45% in the commercial samples kindly furnished by the various West Australian manufacturers. Curiously, however, the santalols were not detected in oils of our own distillation. This observation is being followed up, and will be dealt with in a subsequent paper. Messrs. Rao and Sudborough separated two alcohols which they designated as α and β Fusanol, which, with the exception of variation in boiling point possessed constants not far removed from each other. As a matter of fact they appear to approximate very closely to the santalols.

The author's experience seems to show that it is not altogether advisable to characterise alcohols of this nature by optical activity alone, as the figures given for α and β Fusanol are +5.7° and +2.6° respectively. A laevo-rotatory alcohol has been isolated with a specific rotation of −70.4°, being the principal component of a sandal-wood oil obtained from the species *Santalum lanceolatum*, which is used by the West Australian manufacturers to bring the optical rotation of their oils up to the requirements demanded by the B.P. for the East Indian oil.

I have been successful in characterising some of the various alcohols present by the preparation of the respective allophanates, that of the santalols melting at 162-163°, whilst the other alcohols, for which the term Fusanol might be retained, yield similar derivatives melting at 148-152°. On the other hand that from the laevo-rotatory alcohol referred to above is a most beautiful crystalline derivative of melting point 114°. With the exception of santalol none of these other alcohols yielded santalenic acid. A dextro-rotatory alcohol of apparently a secondary character was also isolated in small quantity from the Western Australian oil, but it did not yield a crystalline allophanate.

In order that the preliminary results recorded herein may be of practical value, commercial samples of East Indian oil were examined at the same time and under similar conditions. The chemical and physical characters of the respective commercial oils of the W.A. manufacturers are in close agreement, and my experimental work leaves no doubt at all that these oils differ in chemical composition from the East Indian oil, although the santalols are present to the extent of about 45%.

Owing to the divergent views prevailing amongst distinguished botanists in regard to the botanical derivation of this oil, I am omitting in this paper any reference to their controversial views. The work of Sprague and Summerhayes published in Kew Bulletin of Miscellaneous Information, No. 5, 1927 ("Perfumery and Essential Oil Record", July, 1927, page 51) seems to have established the fact that the tree yielding the principal supplies of West Australian Sandalwood oil of commerce is *Eucarya spicata* (Sprague and Summerhayes) (Syn. *Fusanus spicatus*, R. Br.; *Santalum spicatum*, A.DC.; S. *cygnorum*, Miq.).

No valid reason has been advanced as to why the Australian oil cannot find a market on its own intrinsic merits as the product of *Eucarya spicata.* The B.P. authorities should undoubtedly make provision for it in the B.P. under its own generic name, as it is futile to include it under the same heading as the oil of *Santalum album,* more especially as the chemical and physical characters of the Australian oil can be made similar by the addition of the distillate of *Santalum lanceolatum.*

Experimental.

All the specimens of Australian oil examined were commercial samples drawn from bulk by the various West Australian manufacturers, whilst the East Indian lots were purchased in the open market. In every instance they were very clear and bright, moderately viscous and of a bright yellow colour. The chemical and physical constants of each are given in the following table :—

Samples examined.	d^{15}_{15}	a^{20}_{D}	n^{20}_{D}	Solubility in 70% Alcohol. By weight.	Solubility in 70% Alcohol. By volume	Ester No., $1\frac{1}{2}$ hours' hot sap.	Ester No after Acetylation.	Botanical origin.
Commercial Oil—				Vols.	Vols.			
West Australian No. 1 ..	0.9693	−8.35°	1.5055	1.2	2.0	13.4	205.6	*Eucarya spicata*
West Australian No. 2 ..	0.9672	−4.5°	1.5052	1.4	4.5	10.9	197.8	*Eucarya spicata*
West Australian No. 3 ..	0.9662	−1.85°	1.5067	1.3	4.75	9.1	197.6	*Eucarya spicata*
West Australian No. 4 ..	0.9628	−45.7°	1.5085	1.3	4.25	23.5	204.6	*Santalum lanceolatum*
West Australian No. 5 ..	0.9529	−48.5°	1.5068	1.6	4.7	8.4	205.4	*Santalum lanceolatum*
Commercial Oil—								
East Indian No. 1	0.9786	−17.5°	1.5063	1.5	4.0	19.2	208.5	*Santalum album*
East Indian No. 2	0.9778	−18.7°	1.5067	1.5	4.5	15.6	204.8	*Santalum album*
Oil distilled in Sydney Technological Museum from logs furnished by B. & Co. Ltd., Perth	0.9485	−4°	1.5020	2.0	insol. 10 vols.	13.0	179.0	*Eucarya spicata*
Do. do.	0.9446	−61°	1.5055	1.8	7.5	9.3	193.4	*Santalum lanceolatum*

On fractional distillation, at 1-2 mm., of West Australian samples nos. 1 and 2, and East Indian no. 1, the following results were obtained:—

W.A. Oil, No. 1. 400 *c.c. crude oil.*

Boiling Point.	Volume.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}	M.Pt. of allophanate	Yield of Santalenic acid.
110-140°	46 c.c.	0.9338	—8.4°	1.4970	157°	14%
140-145°	62 c.c.	0.9595	—7.2°	1.5031	153°	17%
145½-146½°	40 c.c.	0.9627	—7.6°	1.5051	153°	12½%
146½-147°	142 c.c.	0.9627	—8.0°	1.5058	142–145°	10%
150-156°	40 c.c.	0.9750	—10°	1.5089	—	3%
156-158°	20 c.c.	0.977	—10.8°	1.5100	—	—
Viscous residue				1.5195		

W.A. Oil Sample No. 2. 100 *c.c.*

104-130° (3 mm.)	20 c.c.	0.9372	—4.55°	1.4992
130-147° (3 mm.)	17 c.c.	0.9582	—4.5°	1.5037
148-154° (3 mm.)	53 c.c.	0.9691	—3.8°	1.5068
Residue				1.5142

The East Indian oil distilled under similar conditions gave the following results, viz.:—

No. 1 *sample,* 200 *c.c.*

135-141° (1-2 mm.)	35 c.c.	0.9690	—15.9°	1.5040
141-145° (1-2 mm.)	150 c.c.	0.9785	—17.2°	1.5064
Residue	15 c.c.	0.979	—24°	1.5150

The foregoing results clearly show that there exists a considerable difference in the alcoholic components of the West Australian and East Indian oils.

The three samples of oil referred to above were then treated with equal weights of phthalic anhydride and benzene on a boiling water-bath, using 100 gram lots in each case. All the samples thus treated returned 70% of alcoholic constituents when isolated from the phthalic acid esters. Combination was effected after one hour's treat-

ment, although two hours' heating was given in each case. The following results were obtained when the regenerated alcohols were subjected to fractional distillation under reduced pressure.

Boiling Point.	Volume.	d_{15}^{15}	α_D^{20}	n_D^{20}	Allophanate M.Pt.
W.A. Oil, No. 1.					
130-146° (1-2 mm.)	10 c.c.	0.9622	—5.5°	1.5041	
146-149° ,,	10 c.c.	0.9608	—6.1°	1.5050	
150-154° ,,	40 c.c.	0.9602	—7.6°	1.5058	
Duplicate result.					
Below 151° (3 mm.)	6 c.c.	0.9615	—6.0°	1.5050	
154-155° (3 mm.)	40 c.c.	0.9622	—8.5°	1.5067	151°
W.A. Oil, No. 2.					
135-154° (3 mm.)	14 c.c.	0.9865	Inactive	1.5060	162°
154-156° (3 mm.)	50 c.c.	0.9660	—3°	1.5068	152°
East Indian Oil, No. 1.					
140-150° (3 mm.)	8 c.c.	0.9793	—14.4°	1.5055	
150-155° (1 mm.)	18 c.c.	0.9774	—19.6°	1.5064	162–163°

Oxidation of Crude Oils.

(a) The chemists of the Imperial Institute (Bulletin, Imperial Inst. 1920, 18, 163) found that the Australian oil yielded only 8% santalenic acid as against 20% obtained from the East Indian oil on oxidation with potassium permanganate, using Chapman's process. (The particular sample of oil examined contained only 76-78% sesquiterpene alcohols.) The author repeated this work and obtained similar results, but the amount of tarry products formed with the Australian oil made it very difficult to estimate and purify the santalenic acid. A modified process of oxidation with potassium permanganate was adopted, which not

only gave considerable increased yields of santalenic acid, but the latter was obtained free of tarry products upon treatment of the West Australian oil. The process was as follows:—50-grams of powdered potassium permanganate (70-grams required for the Australian oil) are placed in a winchester with 700 c.c. iced water, 300-grams ice and 20 c.c. of the Sandalwood oil and the mixture transferred quickly to a shaking machine when the oxidation is completed within a few minutes. The following average results were thus obtained:—

20 c.c. of the East Indian oil yielded 6-7 grams of crude santalenic acid,

20 c.c. of the West Australian oil gave 2.5 to 3.5 grams do.

Computing from this basis, the Australian oil is considered to contain about 40-45% of Santalols. The santalenic acid obtained in every instance when purified from ethyl alcohol or acetone and water, melted sharply at 76°-76.5°.

(b) The Australian oil when oxidised with chromic acid in glacial acetic acid solution alongside of the East Indian oil yielded small quantities of aldehyde, the semicarbazone of which melted at 230°, thus affording confirmation of the presence of santalol.

Preparation of the Allophanates.

A study is being made of the action of cyanic acid upon the various alcohols with a view to their definite identification. The work is not yet completed, but sufficient data is available to show that the W.A. alcohols are a mixture of isomeric sesquiterpene alcohols with the santalols. The East Indian alcohols yielded a fine crystalline derivative melting at 162-163°. The Australian oil yielded a mixture

from which on repeated fractional crystallisation a definite fraction of melting point 162° was obtained, identical with santalol allophanate. A mixed melting point showed no depression. The remaining fractions varied in melting point from 148° to 152°, being probably mixtures with santalol allophanate of M.Pt. 162-163°. The laevo-rotatory alcohol to be described under *Santalum lanceolatum* yielded a very beautiful derivative of melting point 114°. Combustion and molecular weight results confirmed their identity as allophanates.

Determination of a Secondary Sesquiterpene Alcohol possessing Dextro Rotation.

All commercial samples of the Australian oil were found to contain a small quantity, not above 10%, of an alcohol which combined with phthalic anhydride only when heated in an oil bath at 140°. The uncombined oil remaining after the separation of the phthalic acid ester of the alcohols which combined with the anhydride in benzene solution on the boiling water bath was again heated with this reagent in an oil bath at 140° The regenerated alcohol for which a high degree of purity is not yet claimed, was found to possess the following chemical and physical characters.

	No. 1.	No. 2.
Boiling point (1 mm.)	145-154°	146-150°
Specific gravity $\frac{15°}{15}$ ..	0.9939	0.995
Optical rotation	+ 18.4°	+ 27.2°
Refractive Index, 20°.	1.5106	1.5100

Neither sample yielded a crystalline allophanate when treated with cyanic acid.

Oils from Wood of own Distillation.

The oil from wood of *Eucarya spicata* when treated with phthalic anhydride in benzene solution on the boiling water bath, yielded 30% of alcohols possessing the following characters:—

B. point (4-5 mm.), 160-161°; specific gravity, 0.942; optical rotation, +4.9°; and refractive index, 1.5039 at 20°.

The oil from wood of *Santalum lanceolatum* gave 70% of an alcohol on similar treatment possessing the following constants:—

B. point, 163-165° (5 mm.); specific gravity, 0.9474; optical rotation, —66.7°; and refractive index, 1.5074 at 20°.

The above laevo-rotatory alcohol gave combustion and molecular results approximating to a formula $C_{15}H_{24}O$. On treatment with cyanic acid an excellent yield of crystalline allophanate melting at 114° was obtained.

As a result of the examination of the above oils distilled from the woods in this laboratory, it is evident that the West Australian oil contains a sesquiterpene alcohol of similar formula to santalol having the following approximate constants:—

B. point, 160-161° (4-5 mm.); specific gravity, 0.942-943; optical rotation, ±5°; and refractive index, 1.5030 at 20°.

A mixture of this alcohol with the santalols would result in a similar mixture of alcohols as occurs in W.A. Sandalwood oil with a specific gravity of 0.962. This particular alcohol has not yet yielded a crystalline allophanate nor santalenic acid on oxidation.

Distinction between Australian and East Indian Oils by means of Colour Reaction for Sesquiterpenes.

Small quantities of sesquiterpenes are present in the Australian oils as is evident by the violet red colour reaction obtained with bromine vapour when the crude oils are dissolved in acetic acid. This colour reaction for sesquiterpenes in Australian essential oils is a very common one, and has been much referred to in the author's com-

munications to this Society. The East Indian oils, however, do not give this colour reaction when tested under the same conditions.

Although the colour obtained is not a very intense one on account of the small quantities of sesquiterpenes present, yet at the present time it offers a ready method of rapidly differentiating the two oils if a quick test be required. The author is very diffident of colour reactions, but has found the present one to be reliable.

In conclusion, I wish to express my best thanks for valuable assistance rendered by the various firms engaged in the Sandalwood oil business, such as Messrs. Plaimar Ltd., Perth, Braddock & Co. Ltd., Perth, and W. K. Burnside Pty. Ltd., Melbourne.

I am also indebted to the Assistant Economic Chemist, Mr. F. R. Morrison, F.C.S., A.A.C.I., for assistance in this investigation.

THE OCCURRENCE OF A NUMBER OF VARIETIES OF EUCALYPTUS DIVES AS DETERMINED BY CHEMICAL ANALYSIS OF THE ESSENTIAL OILS.

PART II.

(With remarks on the Ortho-cresol method for estimation of Cineol)

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(Read before the Royal Society of New South Wales, 4th July, 1928)

EUCALYPTUS DIVES. var. "C".

In our Part I. communication to the Society on the 1st June, 1927 (this Journal, Vol. LXI., page 63), reference was made to the commercial distillation of this form of *Eucalyptus dives,* at Tumbarumba, N.S.W. We questioned the advisability of its distillation on account of the variation in composition of the essential oil due to the periodic occurrence of phellandrene, which rendered it unsaleable as a pharmaceutical oil.

The position with regard to the exploitation of the species, at the time of publication, was a serious one, as the distillers had been forced to close down for the reasons set forth. It was apparent that a field inspection was urgently desired, and accordingly we visited the Tumbarumba district in October, 1927. Previous field experiences enabled us to select belts of country which would be reasonably safe to work as phellandrene and piperitone

could not be detected upon crushing the leaves between the fingers, the exquisite aroma of the blend of cineol-terpineol-citral which emanated therefrom being a characteristic feature of the majority of leaves from selected fields.

Representative samples of the leaves and terminal branchlets were personally collected from a series of belts of country which were examined in the Tumbarumba district in order to check the field observations, and the results set forth in the table afford such confirmation in quite a remarkable manner. This visit, which occupied but a week-end, enabled the distillers to recommence operations, and to provide an excellent source of oil of the *Eucalyptus Australiana* type, for which there is a steadily increasing demand. It is the Eucalyptus oil par excellence for pharmaceutical purposes.

There is a considerable enquiry for high grade water white oils from *E. Australiana* and other species yielding oils similar in physical properties and chemical composition, and the economic aspect of the observations recorded in this paper are of far-reaching importance. It is only a matter of time when this type of oil must replace the "Mallee" oils altogether for medicinal purposes.

Many samples of the oil of *E. dives* and its varieties have been examined since 1917, but not one from this district had been found to be free of cineol and to contain piperitone and phellandrene in abundance, thus approximating to the composition of the oil of the normal *E. dives.* This fact was difficult of explanation up to the time of our field inspection, but a cursory examination of the first belt of country examined soon revealed trees of the type. We view this detection of the Type *E. dives* in this district as an observation of great importance, as otherwise it would be difficult to be convinced of its relationship to variety

"C", particularly on account of the wide divergence in composition of the respective essential oils.

Many of the observations made in the course of the selection of suitable areas for commercial exploitation are worthy of record. Mention was made in our Part I. paper of a clump of 5 trees near Goulburn, 2 of which consisted of the normal *E. dives*, and 3 of Variety "B".

Similar instances were noted at Tumbarumba, an example at School Hill being most striking. A sample of oil had previously been distilled from the leaves and terminal branchlets selected from a clump of seven trees, and on examination had been found to contain a small quantity of phellandrene, thus rendering an otherwise excellent oil valueless for medicinal purposes. The particular belt of country known as the School Hill was found to be in general a very excellent field, the leaves being longer and broader and the trees heavier in leaf than those in other areas. Moreover, from the leaves on crushing emanated the excellent aroma of cineol-terpineol-citral.

It was, therefore, very difficult to account for the adverse report, and a special search was made for the patch of trees from which the leaves had been selected. They were subsequently located, and found to be botanically identical. The first six examined were found to be true to *E. dives*, var. "C"; the seventh, however, was found to be rich in phellandrene (piperitone and piperitol could also be detected, but very little cineol), and to be approximately the variety "B". It is a remarkable fact that if the leaves of the first six trees only had been distilled the oil would have been very favourably reported upon, whereas the admixture of the leaves from the seventh tree resulted in the oil being condemned on account of the presence of phellandrene. (See result in Table.)

Again at Mannus Hill, on the left hand side of the road a number of trees of the type were found growing distributed amongst a preponderance of trees of variety "B" and variety "C", whilst on the right hand side trees of variety "B" were found distributed throughout a belt of variety "C", which predominated. It was a strange experience to crush the leaves of a tree and to note the pronounced piperitone-phellandrene odour, and to compare it with that from a tree but three feet away, the leaves of which, when similarly treated, exhaled the refreshing aroma of cineol with a little citral.

Unfortunately, these most interesting areas of country had, of course, to be rejected as being of no value for commercial distillation at the present time. Other areas of country near Rosewood and Glenroy in the Tumbarumba district consisting almost entirely of variety "C" were selected and recommended for commercial distillation. Summarising the Tumbarumba district as a whole, we can state that the belts of *E. dives* are the diametrically opposite of the better known belts of the type. The latter contain but a small percentage of trees of variety "A" and variety "B" as compared with many of the former, which consist almost entirely of variety "C", with a small percentage of trees of variety "B" and the normal type.

Many analyses made since the reopening of the field in October last on samples representing tons of oil procured from the selected fields have shown phellandrene not to be detected according to the B.P. test, and the cineol content to vary from 60% to 70%. Abundant evidence has thus been provided for the justification of our recommendations based upon field observations.

Determination of Cineol.

Opportunity was taken to determine the cineol contents of the oils by the new ortho-cresol method proposed by T.

TABLE—*EUCALYPTUS DIVES* AND ITS VARIETIES from Tumbarumba, N.S.W.

Date.	Locality.	Yield of Oil.	$d_{15}^{15°}$	$\alpha_D^{20°}$	$n_D^{20°}$	Solubility in 70% Alcohol.	Piperitone Content.	Cineol Content	Phellandrene.	Ester No. 1½hrs hot sap.	Ester No. 1½ hrs. hot after Acetylation.	Remarks.
23/10/1927	Mannus Hill (left hand side of road)	1.62%	0.9099	−42.6°	1.4817	1.4 vols.	52%	—	about 40%	—	—	*E.dives* Type
,,	Mannus Hill (right hand side of road)	3.1 %	0.9077	−21.4°	1.4686	1.4 ,,	8%	24%* (17%)†	abundance	52.2	100.1	*E.dives*, Var. "B"
,,	Nichol's Country	4.2 %	0.9214	+4°	1.4627	1.1 ,,	—	58%	absent	12.1	58.8	*E.dives*, Var. "C"
,,	School Hill (7th tree)	2.32%	0.8904	−36.8°	1.4721	insol. 10 vols.	5%	22%* (11%)†	abundance	12.7	77.1	*E.dives*, Var. "B"

*=Resorcin method. †=Ortho-cresol method.

Tusting Cocking (Paper read before the British Pharmaceutical Conference, 1920; see "Perfumery and Essential Oil Record", August, 1920, page 281). The method has since been reported upon by the Essential Oil Sub-Committee to the Standing Committee on Uniformity of Analytical Methods and the findings published in the "Analyst" for May, 1927.

As a result of our own work we must admit that the method is an excellent one, and in our opinion should certainly be adopted by the B.P. Authorities as a standard method. In a series of experiments conducted with various commercial Eucalyptus oils very good agreement was observed when the method was tested against the older and better known phosphoric acid process. It is necessary to point out, however, that abnormal percentages of cineol were found with oils of the *E. Australiana* type, which, of course, includes *E. dives*, var. "C", due to the presence of α-terpineol. Mr. T. Tusting Cocking in his original paper mentioned that alcohols and esters gave high results, but looked upon the variation as negligible for B.P. oils. In our opinion, the variation is too great to be overlooked, and we would suggest that the determination be made on the portion distilling below 190° when applied to oils of this type, in order to ensure accurate results.

A comparison of the results as set forth in the following table exemplifies our contention in a striking manner, viz.:—

E. dives, var. "C". Crude Oil.

	Congealing Point (U.S.P. Method).	Cineol contents. Phos. acid method.	Cineol contents. Cresol method.	Cineol contents by Cresol method, using portion of oil distilling below 190°.
Sample No. 1 (Nichol's Country)	–17°	57-58%	67.5%	59%
Sample No. 2 (Commercial)	–16°	62-63%	71.4%	64%

Determination of α-Terpineol.

The presence of α-terpineol was confirmed by distilling 200 c.c. of *E. dives* oil, var. "C" (see table), and examining the portion distilling above 190°. After further distillation, 16 c.c. were obtained boiling between 95-110° at 10 mm., and possessing the following constants, viz.:—

$$d\frac{15}{15},\ 0.9383\ ;\ \alpha_D^{20^\circ} + 0.3^\circ\ ;\ n_D^{20^\circ}\ 1.4780.$$

These figures indicate a high content of α-terpineol. The alcohol reacted very readily with both phenylisocyanate and napthylisocyanate, giving good yields of the respective phenylurethane and napthylurethane melting respectively at 113° and 148°. The constituent accompanying the cineol in the fraction distilling below 190° could not be isolated for identification, as on treatment with 50% aqueous resorcin solution the whole went into solution. The additive compound of cineol and resorcin was separated and purified and found to be a very stable combination. It melted at 83°.

The two samples of oil of var. "B" examined were found to be low in piperitone. It is as well to make mention of the fact that in such instances the corresponding alcohol is present. Piperitol is very difficult of separation and identification in the absence of large quantities of crude oil, but is readily detected by its characteristic odour, and consequently we are able to satisfy ourselves of its presence when handling comparatively small quantities of oil and leaves.

In conclusion, our thanks are due to the Forestry Commission of New South Wales and its officer, Mr. Boyd, for providing facilities for the field inspection at Tumbarumba, and to Messrs. F. Heinecke and M. Kinstler for assistance and interest during the visit.

SOME OBSERVATIONS ON THE WOODINESS OR BULLET DISEASE OF PASSION FRUIT.

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(With Plates I-IV)

(Read before the Royal Society of New South Wales, 4th July, 1928)

Commercial production of passion fruit (*Passiflora edulis,* Sims) in N.S.W. is limited practically to the coastal areas. The vines are grown in plantation blocks or are interplanted with citrus in the early years of the establishment of citrus orchards. Many growers have relied upon the crop as their main source of income until their citrus areas have approached the stage of profitable production. There is keen demand for passion fruit on the local market, but in spite of favourable prices for good quality fruit, and in spite of the fact that there are large areas in the State which are suitable for passion fruit production, the supply of fruit is still unequal to the demand. Several attempts also have been made to establish a passion fruit pulp industry and guaranteed prices have been offered to growers for the regular supply of fruit, but these efforts have proved abortive.

The records on production of the crop in N.S.W. have been compiled annually by the Government Statistician for the past 15 years, and this information is shown graphically in text Fig. 1. It will be noted that, although there was a general increase in the number of vines in bearing from 1921-1925, there was not a comparable increase in production during this period. In 1924, 221,178

vines and in 1925, 219,188 are recorded in bearing, and the peak in production was reached in 1925, when 73,079 bushels of fruit were harvested. This figure, however, does not greatly exceed the 58,901 bushels which were harvested in 1920 from 95,257 vines.

The average annual yields per vine have been calculated from the data on production for the past fifteen years and are shown in the following table:—

Passion Fruit Production in N.S.W.
Average Yield per Vine—1913-1927.

	bushels.		bushels.		bushels.
1913 ..	.32	1918 ..	.47	1923 ..	.25
1914 ..	.31	1919 ..	.45	1924 ..	.30
1915 ..	.43	1920 ..	.61	1925 ..	.33
1916 ..	.46	1921 ..	.43	1926 ..	.34
1917 ..	.49	1922 ..	.38	1927 ..	.36

There are records of production in individual plantations in which the yield has exceeded 2 bushels per vine, but the average yield for the State for the past five years is only .31 bushels per vine, thus indicating that there is considerable room for improvement in the methods of production.

It will be noted from the above table that relatively high average yields were obtained during the five-year period prior to 1920. This may have stimulated interest in the crop and thus partly explain the increase in the number of vines planted during the period 1921-25. Subsequent yields, however, have been disappointing, and a decrease in the number of vines planted is now recorded.

Although the passion fruit will thrive on a variety of soil types in this State, the best returns under local conditions only have been obtained when proper attention has been paid to suitability of location, cultural details,

addition of adequate and suitable fertilisers and pruning. There are instances, however, in which the vines have received apparently suitable treatment and yet have failed to produce satisfactory returns. Under average conditions it is considered that the vines are most productive during the first 3 or 4 years of growth. After this period most vines are obviously unproductive and are removed. There are commercial plantations, on the other hand, in which

Passion Fruit Production in New South Wales from 1913-1927.
A.—Production in bushels.
P.—Total Vines in bearing.

the vines are 8-10 years old and are still in a state of profitable production. There are isolated instances, also, of individual vines 15 to 20 years of age which are still producing fruit. In contrast to the above, vines may become entirely unproductive in their first season of growth.

Although lack of attention to cultural details is partly responsible for the relatively poor yields which are now being obtained, it is considered that the present unsatis-

factory position is mainly due to the incidence of disease. Two diseases of passion fruit are of special importance in this connection: (a) Brown Spot caused by the fungus *Gloeosporium fructigenum* Berk, and (b) Woodiness.

It is difficult to suggest which disease has been responsible for the most serious losses, but it is considered that satisfactory control of these diseases would result in a considerable improvement in production in this State. There is no doubt that the Woodiness disease is mainly responsible for the relatively short period of productiveness of vines under local conditions.

History of the Disease.

The Woodiness disease has long been known as a disease of passion fruit in N.S.W. Allen[1] in 1901 described several features of a deterioration disease in passion fruit, and a few months later Cobb[6] published a more complete description of the trouble and also stated that the disease was known to have occurred in the State prior to 1893, and was even then a matter of serious concern to growers. The disease is now known to occur throughout the eastern States of Australia, but apparently causes most serious damage only in N.S.W.

Symptoms of the Disease.

The Woodiness disease of passion fruit was thus named by Cobb (loc. cit.) in allusion to the condition of the fruits which are produced on diseased vines. The condition is most commonly observed during the cooler months of the year, although severely diseased plants may be observed at any time of the year. Individual vines only may be affected, or the disease may affect all the vines in a plantation. The Winter crop of fruit is more severely affected with Woodiness than is the case with the Summer crop. It has also been observed that slightly affected vines which

previously had produced woody fruits may subsequently produce normal fruits during the warmer months. Such vines, however, are not as productive as those which have not been affected with the disease.

(a) *The Fruit.*

Fruits which are ripened on normal vines are dark purple in colour, somewhat ovoid in shape, and are generally symmetrical in appearance. On drying slightly these fruits become shrivelled in a characteristic manner (Plate 1, Figs. 1 and 2).

Woody fruits, on the other hand, are generally misshapen and deformed. Such fruits are often undersized and when not obviously malformed may be somewhat spherical in appearance. This symptom has given rise to a second common name by which the disease is known, viz., "Bullet". The surface of the fruit may be smooth as in the case of normal fruits, but more generally it is characterised by the development of cracks and occasionally by the development of irregularly shaped areas of tissue which appear to have burst through the skin of the fruit (Plate 1, Figs. 3 and 4). The colour of the woody fruits may be almost normal, although generally such fruits develop an abnormal purplish colouration in contrast to the natural colour of healthy fruits. Woody fruits are characteristically hardened, offer considerable resistance to pressure, and, in contrast to normal fruits, are not readily cut through. Such fruits on drying do not shrivel uniformly in the manner described for healthy fruits. When abnormal fruits of this type are cut through, the tissues of the pericarp or rind are noticed to be abnormally thickened (Plate 2, Fig. 5).

Each seed in a normal fruit is surrounded by a bright yellow-coloured arillus which in the mass constitutes the

edible pulp of the fruit and which possesses a characteristically piquant flavour.

Woody fruits, on the other hand, contain a much smaller quantity of pulp, which is somewhat orange in colour and through which the black-coated seeds are more readily observed. The flavour of the pulp of such fruits is insipid and undesirable. In some cases the woody fruits may be practically devoid of contents, although superficially there may be little to distinguish them at times from the fruits of a normal plant. Many of the seeds of a diseased fruit are undeveloped. Although the abovementioned features refer particularly to the mature fruits, symptoms of woodiness also may be observed in fruits which are in the early stages of development. Such fruits are deformed, the pericarp shows signs of abnormal thickening, and many may fall from the vine before reaching maturity

Histological studies of the pericarp of abnormal fruits indicate that it differs materially from that of a normal fruit. In transverse section the pericarp of a normal fruit is seen to be composed of (a) an outer epidermal layer one cell wide, and then a subepidermal layer three cells wide, immediately underlying which is (b) a hypodermal band of small, rounded, thick-walled sclerenchymatous cells approximately three cells wide, and then (c) a much wider section of parenchymatous tissue which also includes the vascular elements (Plate 2, Fig. 6). In abnormal fruits extensive changes are observed to have occurred in the tissues which constitute the innermost section of the pericarp. The cell walls of this altered tissue are thickened and pitted, and the cells are either devoid of or almost devoid of normal contents.

Tests with an alcoholic solution of phloroglucin followed by hydrochloric acid, and tests with usual staining reagents, indicate that these cells are strongly lignified.

The lignification may be restricted to cells adjacent to the hypodermal layer of sclerenchymatous tissue or it may extend throughout the whole of the inner portion of the pericarp (Plate 2, Fig. 7).

(b) *The Foliage.*

The foliage of diseased vines is also abnormal. Such vines have a general appearance of unthriftiness and appear also as if suddenly checked in growth. The leaves of the terminal shoots may be stunted and are frequently curled, twisted and deformed. Changes may occur in the chlorophyll-bearing tissues which result in the development of a yellowish green chlorosis, or there may be formed a definite mosaic of abnormally light green and dark green areas on the leaf. The tissues of the leaf between the veins may be raised or sunken, thus giving the leaf a puckered or crinkled appearance (Plate 3, Figs. 8 and 9; Plate 4, Fig. 10). Light yellowish green spots may develop on older leaves which previously were full-grown and otherwise quite healthy in appearance. The stems of affected plants, particularly in the region of terminal shoots, may develop mottled dark green areas which are in marked contrast to the normal green colouration of healthy plants. These foliar symptoms have been observed under field conditions both in seedlings and in aged vines.

Nature of the Disease.

Many different theories have been advanced as to the causal nature of the disease. Allen[1] suggested that the disease was most serious in vines which were planted in exposed positions in which they were subjected to high winds. Frosts and cool nights at the time of setting of the fruit were considered as a possible cause of the disease, particularly on vines impoverished through age or lack of adequate fertilisers. Insufficient moisture and the influence of hot and dry summers were also considered of impor-

tance. The same writer[2] has also stated that "plants raised from seed from selected vines and planted out with every care have been known, owing to hail followed by drought, to have developed "bullet" at a very early stage and never to have made a payable return". Cobb[6] has reiterated and discussed these possibilities, and has also figured an undetermined fungus which he had found in association with diseased fruits.

In the present study, although the characteristic features of the disease did not indicate that the condition was due to the action of a parasitic bacterial or fungus organism, tissue platings and other observations were made to provide further information in this respect. In no instance was any organism isolated which suggested a causal relationship in this connection.

Infection Experiments.

The foliar symptoms of diseased plants indicated that the "Woodiness" disease might be due to the action of a virus. In November, 1926, a series of inoculation experiments were initiated with a view to determining whether this was the case. Water infusions were prepared from diseased leaves, and from fully-developed and partially-developed woody fruits, and small quantities of this material were inoculated into the stems of healthy plants, but in no case did disease develop. In view of subsequent tests it is possible that the temperatures experienced during the incubation period of the tests were unfavourable for the development of symptoms.

The results of the first series of successful experiments in this connection are indicated below. As in previous instances, seed was obtained from normal fruits and the test seedlings were raised in an insect-proof glass-house. Plant tissue infusions were prepared from leaves and fruits

of diseased vines. The tissues were cut up finely, covered with tap water, and the extract was then decanted and used as inoculum.

The method of inoculation was similar to that described by McKinney.[10] A few strands of sterile cotton wool were soaked in the tissue extract and were then placed in the axil of a leaf of the plant, and then inserted in the vascular region of the stem by means of a needle. Special precautions were taken to avoid contamination in the separate test series. Check plants comprised uninjured seedlings, seedlings in which the stems were punctured with a sterile needle, or in which were inserted strands of sterile cotton wool soaked in water.

Nine seedlings were inoculated on the 13th April, 1928, in the manner described above, using leaf tissue extract as inoculum. Ten days later the first signs of disease were noted in the developing leaves of three plants. On the following day all of the nine plants were showing definite signs of infection. The leaf blades in all cases were very much curled downwards, the tips of the young leaves being pressed up against the base of petioles. Further changes developed in these plants within the following two weeks. Elongation of the stems was checked; some of the newer leaves became chlorotic, while others developed marked mosaic mottling and others showed puckering of the tissues between the veins and other distortions of the laminae.

Five weeks after commencement of the test it was noticed that small yellowish spots were developing on the mature leaves of the inoculated plants. Six check plants in this test and thirty-six untreated plants growing under the same conditions remained healthy. The check plants were still healthy two months later (Plate 4, Fig. 11). Similar results were obtained in a further test with diseased leaf tissue collected from vines in another locality. Four

plants were inoculated on the 7th May, 1928, and pronounced symptoms of disease were noted fifteen days to twenty-four days after inoculation. Four check plants remained healthy.

Tests with water extracts of the tissues of woody passion fruits also produced similar results. Six plants were inoculated with the water extract from woody fruit tissues on the 4th May, 1928, and definite symptoms of disease similar to those already described were noted in all six plants twenty to twenty-seven days after inoculation. Four check plants remained healthy. Further tests are in progress with filtered extracts derived from the tissues of diseased plants.

During the course of field studies on the disease it was observed that certain plants of another species, viz., *Passiflora coerulea* Linn, showed a diseased condition of the foliage which resembled somewhat a mosaic condition occasionally seen on the commercially cultivated vines of *Passiflora edulis.* A plant tissue extract was prepared from the foliage of these abnormal plants and was used in an infection experiment with seedlings of *Passiflora edulis.* Six plants were inoculated on the 13th April, 1928, and marked symptoms of disease similar to those described in previous tests were observed on four plants thirteen to twenty days after inoculation. Six check plants remained healthy. All check plants throughout each of these series of tests have remained in a healthy condition and are still normal.

Masking of Symptoms.

It will be noted that the incubation period varied considerably in respect of the several infection experiments reported above. In some plants definite signs of infection appeared 10 days after inoculation, and in other cases infection was not recorded until 27 days after inoculation.

In the first series also it was observed that, although marked foliar symptoms of disease had appeared in all inoculated plants eleven days after inoculation, the new growth which had developed 30 to 40 days after inoculation was apparently normal. Subsequent growth in these plants has since developed diseased symptoms similar to those which had first appeared in the plants.

No facilities were available for maintaining uniform temperature conditions during the progress of these tests, but thermographic records were maintained throughout this period. No definite correlations can be made between the development of symptoms and the prevalence of definite temperatures, but it is significant that temperatures in excess of 80° F. were experienced prior to and during the period in which normal leaves were developed on plants which were known to be infected with the disease. The variation in the incubation period reported in the later infection tests is considered to be mainly due to the influence of the air temperatures to which the plants were exposed.

Similar phenomena have been observed under field conditions. New, apparently healthy shoots have been produced on diseased vines at various periods throughout the year. As previously indicated also, the disease is typically one which is most serious during the Winter months, and plants which have produced abnormal fruits during this period may produce normal fruit during the Summer months.

DISCUSSION.

It is considered from the evidence reported above that the Woodiness disease of passion fruit can be attributed to the action of a virus. The virus has been proved to be present in the leaves and shoots of vines which have produced woody fruits, and these fruits have also been proved

to contain the virus which, on inoculation into healthy plants, has resulted in the development of the characteristic foliar symptoms of disease. A number of the inoculated test plants are being retained to determine whether the disease will be developed in the fruits which they may develop at a later period. It is considered, however, that the disease is of sufficient importance to justify an announcement of the results which already have been obtained.

A Mosaic disease of Passionflower in England is listed by Bewley,[5] but no further information as to its character has been available to the writer.

The general foliar symptoms of plants in the present study are characteristic of those which have been discribed in a large number of cultivated plants known to be affected with a virus disease.

In the infection experiments it was noted also that the symptoms of the disease in the inoculated plants varied from time to time in different plants, and at the conclusion of the tests some plants were observed to be very much more severely affected with the disease than was the case with others. Although this may be explained in part on the basis of partial masking, it is possible that the virus used on the tests was a mixed one, but further data is required before this aspect of the problem can be elucidated.

Lignified cells or stone-cells are known to occur normally in a wide variety of plants. Artschwager[3] mentions that the presence of such cells in potato tubers may be regarded as a normal varietal characteristic. Their occurrence in certain varieties of pears is also a well-known phenomenon, although their excessive development in these fruits may result in the production of a diseased condition known as Lithiasis, which generally is attributed to the incidence of unfavourable environmental conditions.

The occurrence of lignified cells in tissues which do not normally contain them, however, may be due to the influence of diseases of the virus type. Artschwager,[4] in studies on the changes which develop in potatoes affected with phloem necrosis, has described an abnormal tissue development which consisted of a progressive lignification of cells in the phloem region, and he records also a conclusion reached by Quanjer (loc. cit.), that the lignification of the cells of the phloem is a dependable diagnostic symptom for the identification of leaf-roll, a serious virus disease affecting this crop.

The extensive lignification of the tissues of the pericarp of woody passion fruits would appear also to be another definite manifestation of the effects of a virus disease.

The masking of symptoms such as has been noted in the case of the Woodiness disease is also a characteristic feature of many virus diseases affecting cultivated plants, and this phenomenon has been recorded by a number of observers.

Johnson[8] has shown that manifestation of symptoms in several different types of plants affected with virus diseases depended on the air temperatures to which they were exposed. Critical temperatures varied according to the type of plant under investigation. Tompkins,[13] in a series of temperature control experiments, demonstrated that relatively short exposure to air temperatures in excess of 24° C. was sufficient to mask development of symptoms of mosaic in potatoes. Subsequent exposures to low temperatures enabled mosaic symptoms to appear again. Wilcox[14] also records a masking effect of high temperatures in relation to development of mosaic symptoms in raspberries, and quite recently Plakidas[12] has recorded that strawberry Xanthosis (Yellows) is due to the action of a virus, the effects of which are masked by exposure to temperatures

above 80° F. (24° C.). Elmer[7] has reviewed the results of previous workers in this connection, and, in a discussion of the results of his own experiments with tomatoes affected with mosaic, suggests "that plants growing in optimum environmental conditions for vegetative growth will exhibit symptoms after a shorter incubation period following mosaic infection than will plants that are not making a vigorous growth".

The masking of symptoms of the Woodiness disease under commercial conditions is of special practical significance. Passion fruit plants may be affected with the virus and may show but little signs of infection during the Summer months. These vines may be pruned severely in October or November with a view to the production of a heavy winter crop. Such action, however, might be quite disastrous owing to the high proportion of woody fruits which may develop in this crop, whereas a more profitable return might have been obtained from the vines had they been allowed to mature the summer crop in a normal manner.

Two other destructive plant diseases recently investigated in Australia have been proved to be due to the action of parasitic viruses, e.g., Bunchy Top in bananas and Spotted Wilt of tomatoes. Both of these diseases, however, could only be reproduced consistently in infection experiments by means of an appropriate insect vector.

Magee[9] demonstrated that Bunchy Top was transmitted by means of the banana aphis (*Pentalonia nigrovenosa* Cql.), and Pittman,[11] in trials with a number of potential carriers of the virus of Spotted Wilt, showed that this disease was transmitted by means of the rose thrips (*Thrips tabaci* Lindeman).

In the case of the Woodiness disease it has been shown that, under suitable conditions, the virus which causes the disease may be transmitted mechanically.

Under field conditions it is possible that the disease is transmitted in a number of different ways. The rubbing of the shoots of diseased vines against the adjacent shoots of healthy vines may be a prolific source of infection. Growers may unwittingly transfer the disease during pruning operations, and particularly when rubbing off the laterals in the early stages of growth of vines when the latter are being trained on to the supporting wires. Insects which feed on the diseased vines and then migrate to healthy vines may occasionally also result in transmission of the disease, although further information in this respect is not yet available.

Suggestions for Control of the Disease.

The present status of this investigation makes it possible for several suggestions to be made in reference to control measures:—

1. Seedlings should not be raised in proximity to diseased vines. Severely diseased seedlings frequently have been observed in such locations.
2. Only healthy seedlings should be planted out. Symptoms of the Woodiness disease can be readily detected in seedlings in the Spring, and any diseased plants should be immediately removed and destroyed.
3. Careful systematic inspections should be made of the vines in young plantations, and any vines which are stunted in growth or which show signs of foliage abnormality of the types already described should be removed and destroyed.
4. Very careful observations should be made of vines at the time of pruning, particularly in the first season of

growth. It is most likely that infection may be carried on the hands of those working among the vines, and care should be taken to wash the hands well in soapy water after dealing with a diseased vine and before working with healthy vines. Field evidence supports the view that replacements can be safely made shortly after removal of diseased vines.

5. When the plantation is more than one year old, the vines generally have become entangled with one another on the wires. The removal of a diseased vine then becomes a matter of extreme difficulty, and it is questionable whether this is desirable. Removal can hardly be effected without injuring the shoots of adjacent vines in the row and thus increasing risks of infection. If there are but few of such vines present it would probably be preferable to cut them off at the roots and then to remove the vines several weeks after they had dried out. Removal of the diseased vines in this condition then would be less likely to result in infection of the adjacent vines. However, when infection is widespread throughout a plantation, all vines should be destroyed as soon as practicable; but if the crop indications are such that an immediate return appears possible, efforts should be made to concentrate on the Summer crop from such an area. A plantation in this condition should not be pruned with a view to forcing a Winter crop, as such a crop would be practically valueless. Neglected plantations and even isolated vines showing evident signs of deterioration constitute a very real menace in the perpetuation of the Woodiness disease, and every effort should be made to destroy vines in this condition.

6. It has been demonstrated that the Woodiness disease may be transmitted mechanically; thus it is possible

that a number of agencies may be concerned in the transmission of the disease under field conditions. Although the passion vine is not normally subject to serious visitations by insect pests, insects may at times be concerned in the transmission of the disease. It is generally impracticable to apply sprays effectively to vines growing under commercial conditions, owing to the impossibility of obtaining satisfactory distribution on the dense mass of foliage. As a measure of good cultural procedure, however, all weeds which might act as harbours for insect pests should be kept down as much as possible.

Summary.

1. Passion fruit production in N.S.W. is an industry of special local importance, but although satisfactory returns occasionally have been obtained by individual growers, the returns in most instances are disappointing. The position is well illustrated by the data on production for the State.

2. The average annual yield per vine for the 5 years' period 1923-1927 was .31 bushels. Records from individual plantations have exceeded 2 bushels per vine.

3. There is an increasing demand for the fruit, but the returns obtained by growers have resulted in discouragement, and the industry as a whole is in a somewhat languishing condition.

4. This condition is considered to be due mainly to the incidence of two diseases which affect the crop, viz., Brown Spot caused by the fungus *Gloeosporium fructigenum,* and a disease known as Woodiness or Bullet. The latter disease has been the subject of the present study.

5. Woodiness was known to occur in N.S.W. prior to 1893, and it is still a serious limiting factor in production.
6. Symptoms of the disease may be recognised in the general deteriorated appearance of affected vines, in abnormalities of the shoots and foliage, and in the woody character of the fruits.
7. Many theories have been advanced as to the nature of the disease, but infection experiments have demonstrated that it is due to the action of a parasitic virus which, under appropriate conditions, can be transferred mechanically.
8. Symptoms of the disease may be masked during the incidence of air temperatures above 80° F., thus indicating a possible reason for the prevalence of the disease under field conditions during the cooler months of the year.
9. A number of suggestions are made with a view to minimising losses experienced as a result of the occurrence of the disease.

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EXPLANATION OF PLATES.

Plate 1.

Fig. 1. Normal mature passion fruit.
,, 2. Normal mature passion fruit after slight drying.
,, 3. Woody passion fruit.
,, 4. Woody passion fruit showing cracking of the rind.
(All natural size.)

Plate 2.

Fig. 5. Upper: Woody passion fruit cut across. $\times \frac{2}{3}$.
Lower: Normal passion fruit cut across. $\times \frac{2}{3}$.
,, 6. Transverse section of outer portion of pericarp of normal passion fruit. $\times 55$.
,, 7. Transverse section of outer portion of pericarp of Woody passion fruit. $\times 60$.

Plate 3.

Fig. 8. Terminal shoot of passion vine severely affected with the Woodiness disease. $\times \frac{1}{2}$.
,, 9. Terminal leaves of passion vine, (left) healthy, (right) affected with the Woodiness disease. $\times \frac{2}{3}$.

Plate 4.

Fig. 10. Mature leaf of passion vine affected with Woodiness, showing puckering of tissues between the veins. $\times \frac{2}{3}$.

Fig. 11. Passion vine seedlings 2 months after commencement of an infection test. (Left) Check healthy. (Right) Three plants affected with the Woodiness disease. $\times \frac{1}{9}$

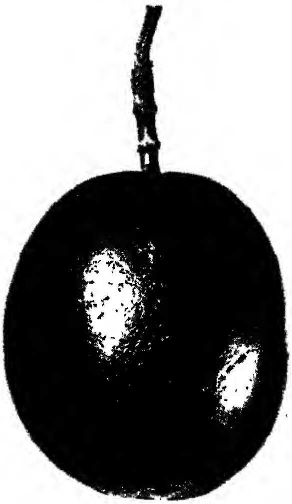
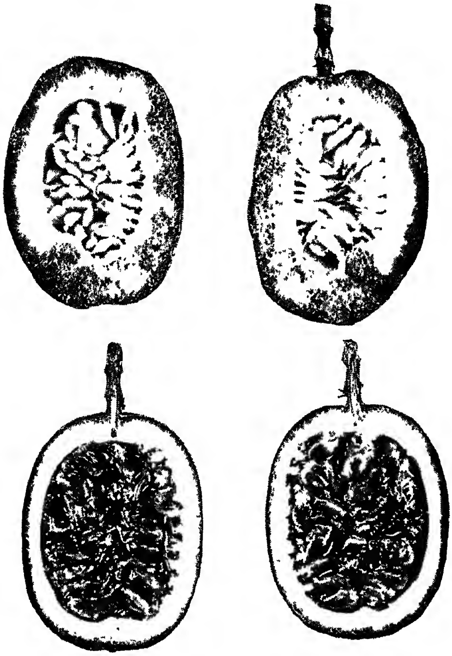


Fig. 1.

Fig. 2.

Fig. 3.

Fig, 4.



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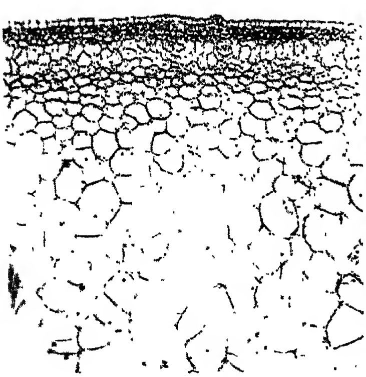


Fig. 6.

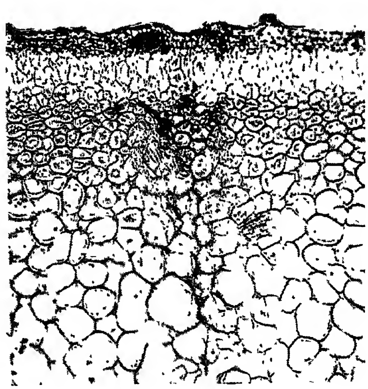


Fig 7.

Fig 8.

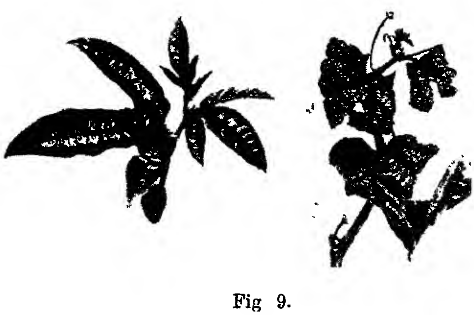


Fig 9.

Fig 10.

Fig. 11.

BROWN ROT OF FRUITS, AND ASSOCIATED DISEASES, IN AUSTRALIA.

PART 1. HISTORY OF THE DISEASE AND DETERMINATION OF THE CAUSAL ORGANISM.

By T. H. HARRISON, B.Sc.Agr.

(With Plates V-IX and one Text-figure.)

(*Read before the Royal Society of New South Wales, August* 1, 1928)

INTRODUCTION.

Brown Rot is a limiting factor in production of drupe and pome fruits in many parts of the fruit growing world, including the temperate eastern and south-eastern fringe of Australia.

This is due to the following facts:—

(1) It has enormous potentialities for wholesale destruction of fruit approaching maturity in the orchard, in transit, in the markets and in the retail shops.

(2) It is associated with serious twig blighting of susceptible varieties of several fruits.

(3) It is associated with "blossom blighting" and resultant crop shrinkage or failure.

(4) Under certain conditions, it is extremely difficult to control.

Brown Rot is a disease which cannot escape detection, and hence we find that, as early as 1796, Persoon (34) wrote of this disease causing rotting of English plums, peaches and French pears in Europe. Throughout the 19th century, other pathologists drew attention to the disease. Contributions were made by Ehrenberg, 1818 (18),

Bonorden, 1851 (7), Hallier, 1876 (22), Schröter, 1893 (42), Frank and Kruger, 1899 (20), Sorauer, 1899 (44), and Woronin, 1900 (53) in Europe: and by Peck, 1880 (33), Smith, 1889 (43), and Pollock, 1900 (36) in America.

Early in the 20th century came a new era of Brown Rot study. In 1902, Norton (29, 30) in America, rediscovered the apothecial stage of the responsible organism. Since then many authors have assisted in accumulating the present considerable store of knowledge concerning the organism and the disease it causes. A few of the more important were Aderhold and Ruhland, Eriksson, and Wormald in Europe; and Norton, Reade, Pollock, Matheny, Jehle, Bartram, Conel, Valleau, Cooke, Brooks and Cooley, Willaman, Ezekiel, Barss, Roberts and Dunegan, and Rudolph in America.

The object of this paper is to present certain fundamental considerations in connection with Brown Rot in Australia.

HISTORICAL—THE DISEASE IN ANSTRALIA.

From the earliest days of settlement in this 140 year old colony, fruit growing has occupied a prominent position. With the first fleet, Governor Phillip brought to these shores fruit trees which he obtained from England, Rio de Janiero, and The Cape. Surprising was the facility with which the introduced fruits grew in the new country, where practically no indigenous edible fruits existed. Stone fruits apparently thrived, for in 1803 Caley (8) reported "the fruit that had succeeded beyond expectation was the peach". In 1807 Luttrell (28) wrote that the principal fruits growing included peaches, apricots, nectarines and plums. In the early twenties of last century Alan Cunningham was so impressed with the excellence of the peaches and the ease with which they could be grown, that he scattered seeds in suitable positions on his exploratory trips inland. At this time commercial fruit growing was

mainly restricted to the Ryde and neighbouring districts along the Parramatta River, within easy reach of the only market—Sydney. As settlement spread, and transport facilities increased, the area devoted to fruit growing extended. By the 'eighties, fruit growing was well distributed over the County of Cumberland and in its neighbourhood, as far as Kurrajong and Penrith on the west and Gosford on the north—approximately within a 45 miles radius of Sydney.

During this developmental period many orchards, of stone fruits particularly, were planted by hard-working men. Not only was good land cheap, abundant and easy to obtain, but labour costs were low. In many cases, however, the orchardist had little or no knowledge of fruit growing, and paid no regard to the limitations of a purely local market. As a natural consequence production outdistanced demand to such an extent that many of the orchards, particularly the older ones, became unprofitable. In many cases these orchard lands were bought by speculators, companies, etc., for subdivision purposes. The result was the same. Not only was no attention given to the trees, but the fruit, in many cases, was not harvested.

Into this chaotic state of affairs the Department of Agriculture was born in 1890. One of its earliest actions was the appointment of Dr. Cobb as consulting pathologist for fruitgrowers and other farmers. In 1897 Dr. Cobb (9) drew a vivid picture of the menace that over 10,000 acres of abandoned orchards situated within 25 miles of Sydney were to the healthy trees of the genuine fruitgrower in New South Wales. Dr. Cobb recognised that the climate of Sydney, with its rainfall of 48 inches well distributed through the year, was ideal for the development of fungi causing fruit diseases. His appeal for the destruction of the trees was without avail, for no legislation existed to

enforce the destruction of the trees in these areas. In fact not until the enlightened days of 1924 (4) was adequate provision made for registration of all orchards and the destruction of neglected trees.

The Introduction of "Brown Rot."

The neglected and abandoned orchards contained a large quantity of stone fruit trees. To the ideal propagating ground thus provided the Brown Rot organism was introduced in the nineties of last century. McAlpine (28) was the first in Australia to recognise the disease. He collected infected apricots from near Melbourne, Victoria, in 1896. In 1898 Allen *et al.* (3) published a brief description of the disease. This is the first one published in Australia, but it is not clear from the context, that the disease had been seen in this country. In 1902 McAlpine (28) published a popular account of the disease and a technical description of the fungus responsible. He stated that the organism was found on peaches, plums, apricots and cherries, and that it caused not only rotting of the fruit but also blighting of the twigs and withering of the blossoms. He recognised that warm, moist weather favoured the development of the fungus.

The next mention of the disease is by Cobb (10), who in January, 1904, wrote, "The Brown Rot has come under notice in this State (N.S.W.) from time to time for a number of years, but it seems that it is only during our moist seasons or in moist districts that it is to be feared." It appears to have been common on all stone fruits, for he stated, "The disease appears with us to be quite as common on the cherry as on any other fruit, and the damage done is quite considerable."

For the next few years nothing was written of the disease, but with characteristic virulence it made its presence felt in 1908. Froggatt (21) in 1909 wrote, "This

disease appeared very suddenly in many different districts just before Christmas (1908) . . . and there was a widespread infestation all through the orchards along the Hawkesbury River. Early in January the trees were covered with dead branches and dried-up fruits, but the disease had stopped spreading due to excessively hot weather just after the New Year. The nectarines suffered particularly . . . a number of trees had died. Peaches were affected in the same manner though less severely, while in the Japanese plums the fruits only were rotted."

In the late summer of 1910 Johnston (25) wrote, "The commonest fruit disease in our markets just now is the Brown Rot, produced by . . . *Monilia fructigena.* This parasite occurs on the following fruits in New South Wales, viz., peach, nectarine, ordinary plum, Japanese plum, cherry, apple and pear, especially on the first four named." Photographs of progressive stages of the rot in peaches and nectarines are shown. The epidemic is ascribed to "warm, moist weather which prevailed."

The next mention of the disease is by Allen (2), who in January, 1912, wrote, "This fungus disease has shown up earlier this season and in a more virulent form than for many years." A strong warning is issued to growers about the necessity for thorough treatment to check the disease.

Season 1913-14 was exceptionally dry and thus we find that Brown Rot was innocuous, but in season 1914-15 a serious epidemic was experienced. Darnell Smith (15) wrote in 1915, "There is no doubt that Brown Rot is the most serious disease of stone fruits in this State as it is in the rest of Australia and elsewhere. . . . While every season there is more or less rot present, the season just closing, owing to exceptional weather conditions, has been a very disastrous one for many orchardists. Peaches, plums, nectarines and cherries have all been severely

attacked. In one orchard it is estimated that 1,200 cases of cherries were lost. . . . During the months of December, 1914, and January, 1915, there was a succession of hot, humid days with occasional showers and cloudy days." Meteorological data are presented from which it is seen that the spring months, September and October, had 7 inches rain above normal and that in December 4½ inches rain above normal fell. In the same season in Victoria specimens were received from many different fruit growing centres, but it was not until 1918 that a serious epidemic swept through the orchards south of the Divide in Victoria. In that year in two orchards alone in one district near Melbourne £7,000 worth of peaches were destroyed and the local peach cannery was not able to operate. Other serious epidemics in the southern State occurred in 1922 and 1923, when losses experienced were exceptionally heavy in cherries and plums. In 1924 the first epidemic occurred in districts north of the Divide, but the disease had first made its appearance there in 1921.*

The history of the disease in N.S.W. continues as follows: Spinks (45) in 1917 wrote, "The season 1916-17 will long be remembered by fruit growers as one of the worst experienced—due to heavy crops, low prices and 'Brown Rot'. . . . Fully 30% of the season's crop was lost in consequence of the ravages of 'Brown Rot'." Season 1917-18 was also favourable to Brown Rot, for Darnell-Smith (16) in 1918, in giving notes on some experiments for the control of Brown Rot in transit, remarked, "Fortunately, as far as the experiment was concerned, Brown Rot was very prevalent." The next season 1918-19 was very dry. During the six months, August to January, only 5 to 7 inches of rain fell, of which less than 2½ inches fell during

* From a report by Mr. S. Fish, Asst. Pathologist, Dept. of Agric., Victoria.

the critical months of December and January. Brown Rot, although present, did practically no damage. In 1919-20, however, favourable conditions for the fungus returned once more. During the critical months 8 to 10 inches of rain fell and extensive damage resulted. It is estimated that in some districts that year the losses amounted to 50% of the stone fruit crop, while apples, pears and quinces were also attacked. The next season (1920-21) was one of phenomenal rainfall. During December and January 16 to 19 inches of rain fell. Fruit, which was cracked by the rain, was readily attacked by the Brown Rot organism, and losses in apricots, plums, nectarines and peaches were again very heavy.

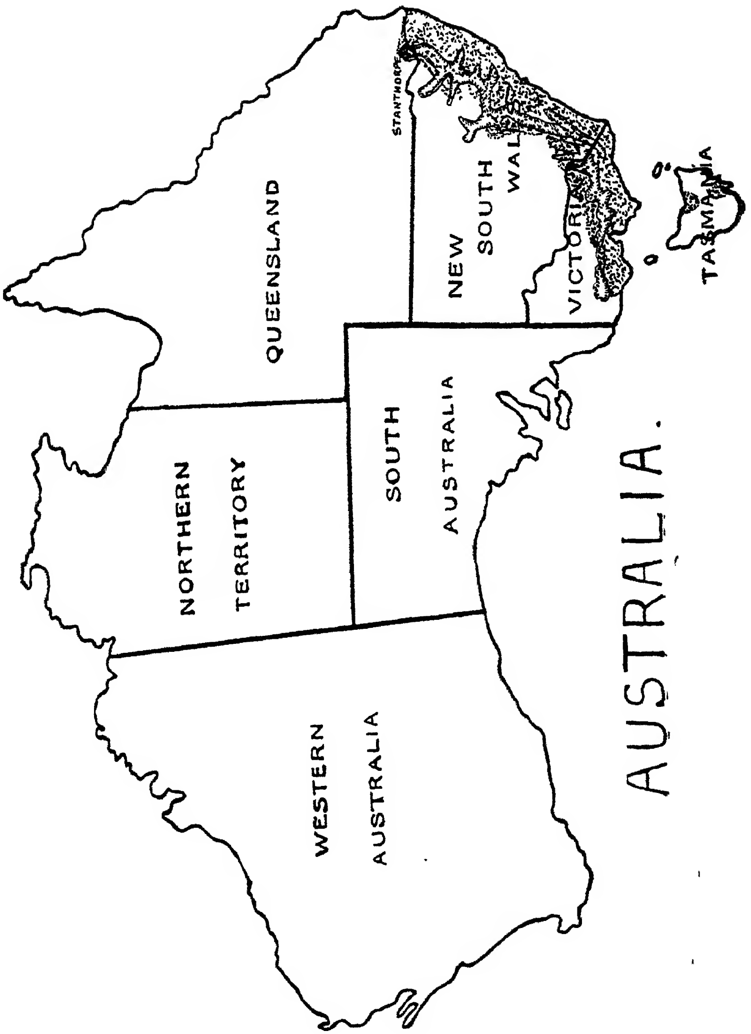
In the spring of 1921 the apothecial stage of the causal organism was, for the first time in Australia, found near Sydney (23). The season which followed was at times very favourable to Brown Rot. Abnormally moist weather was experienced during the latter part of December and early January. At this time much of the early stone fruit crop was approaching maturity. In many cases orchardists in the neighbourhood of Sydney lost heavily. These three seasons of heavy Brown Rot losses were followed by several years with very little damage resulting from Brown Rot.

With season 1927-28 a return to conditions favourable to Brown Rot was experienced. Heavy losses of fruit in the orchard, in transit and in the markets have occurred. In many orchards the twig-blighting has been particularly severe in nectarines and peaches and to a lesser extent in apricots and plums. It is obvious that the severity of Brown Rot infestation in fruit growing areas of N.S.W. depends on prevailing climatic conditions. The results of an attempt to correlate climatic conditions and Brown Rot infestation will be published later. The rainfall registrations quoted above apply only to the fruit growing areas within approximately 45 miles of Sydney, New South Wales.

Present Geographical Range in Australia.

From information gathered from many sources the present approximate distribution of Brown Rot in Australia has been determined. In Queensland Brown Rot occurs "in the Stanthorpe district, the only locality where temperate fruits are grown to any extent".* In New South Wales it appears to be present wherever stone fruits are grown throughout the coast and tableland areas. A detailed survey is at present being attempted. Brown Rot is apparently absent from the Murrumbidgee Irrigation Area. In Victoria it is found in fruit growing areas both north and south of "The Divide", the extension in Victoria of the Main Dividing Range of Eastern Australia. In Tasmania Brown Rot, although present, appears to do but little damage—possibly because most of the stone fruits are grown only to a limited extent. In South Australia it does not now appear to exist, although McAlpine (28) recorded having specimens from there. On 30/11/'27, Mr. Geo. Quinn, Chief Horticultural Instructor, Department of Agriculture, South Australia, wrote, "As far as I am aware the Brown Rot of stone fruits . . . is not found in this State". This has been verified by the Plant Pathologist to the Waite Research Institute and to the Department of Agriculture in South Australia. In Western Australia the disease does not occur. Mr. W. M. Carne, Govt. Botanist and Plant Pathologist to Department of Agriculture, wrote on 15/11/'27, "I am glad to report that this disease is not known here". The manner in which Brown Rot is restricted to the eastern and south-eastern portion of this continent is illustrated in the text figure.

* From information supplied by Mr. J. H. Simmonds, Plant Pathologist, Queensland Department of Agriculture and Stock.



Map showing the approximate geographical range of Brown Rot in Australia, as determined in 1928.

Host Range.

From the fruit growing districts of New South Wales the Brown Rot organism has been isolated by the author from the *fruits* of apple, apricot, blackberry, cherry, nectarine, peach (commercial), peach (ornamental), pear, plum (English and Japanese and prune), and quince. Artificial infection of the fruits of grape, loquat, persimmon and tomato has been produced. The organism has been isolated from *twigs* of apricot, nectarine, peach, plum and quince, and from the *blossoms* of apricot, nectarine, peach and plum. Cankers have been noted on limbs of apricot, nectarine and peach. A brief statement of the relative severity of Brown Rot and associated troubles on various hosts in New South Wales follows:—

Apples.—In the main pome fruit areas of the Tablelands, Brown Rot is not a serious disease. On the coast, however, in some varieties of apples such as Carrington, and Trivett's Seedling, the losses may be very heavy. As much as 50% loss has been noticed. These varieties are grown to a limited extent for the early market and are very popular in householders' gardens around Sydney. The excessive shade and moisture, so often present there, favour the disease. Blighting of spurs on which fruits have been rotted is not uncommon.

Apricots.—This crop is very susceptible on the coast of New South Wales. Should favourable weather conditions occur early enough, Brown Rot will totally destroy the crops. In 1919-20 the author saw approximately 500 bushel cases destroyed in one orchard alone, and again in 1927-28 approximately 800 cases in another orchard in a separate district. Twig-blighting does occur, but is usually not so serious in apricots as in certain varieties of peaches and nectarines.

Blackberry.—This berry is not grown commercially in N.S.W., but the plant is prevalent as a weed of neglected areas of coast and tablelands, in many cases occurring along creek banks, in depressions, etc., in rough country. The fruit ripens in early autumn at a time when the air is thick with spores of the Brown Rot organism. On two separate occasions in 1922, the author found numerous specimens of infected fruits which were covered with pustules. Cultures of the common Brown Rot organism were easily obtained.

Cherry.—The author has had little personal experience of the effects of the disease on cherries. Darnell-Smith (15) records that heavy losses occur, while Johnston (25) makes a similar inference. Officers of the Fruit Branch of the New South Wales Department of Agriculture regard Brown Rot of cherries as the most serious fungus disease of that crop. As cherries are grown in colder and relatively drier climates (e.g., Orange, Young, N.S.W.) favourable conditions for development of the disease are of rare occurrence, but the very nature of the fruit and its method of production make for rapid spread of the disease. Specimens received for cultural purposes showed the typical pustules.

Nectarine.—The experience in the coastal districts of N.S.W. is that this crop is very susceptible to Brown Rot damage. Several writers have mentioned this fact (15, 25, 28). In season 1920-21, the author inspected a block of 50 eight year old nectarine trees from which the whole crop was destroyed by Brown Rot. During seasons 1923-24, 1924-25, 1925-26, while little damage was done, Brown Rot could always be found in nectarines. In 1927-28 the author inspected an orchard in which Cardinal nectarines were attacked by Brown Rot just as the fruit was maturing. Not only was the whole crop destroyed, but the trees

were so badly twig-blighted as to give the impression of having been "fired". All the trees in the orchard were cut back to main trunk limbs. Blossom-blighting has been noticed in this crop and cankering of the limbs invariably follows severe twig-blighting.

Peach.—This is one of the most popular of stone fruits in New South Wales, where conditions are almost ideal for its growth. In the coastal districts of New South Wales, fruit-rotting, twig-blighting, blossom-blighting and cankering are at times severe. Numerous instances of severe losses have been recorded in both N.S.W. and Victoria. In 1927-28 heavy losses occurred. In two orchards the author saw 12 year old trees of Brigg's May and Hale's Early lose 80% of their heavy crop to Brown Rot. These trees were so badly blighted as to necessitate cutting back to foundation leaders.

Peach (Ornamental).—In many gardens of coastal N.S.W. the beautiful double flowering peach (*Prunus chinensis* var. and *P. persica* var.) grows to perfection and often a fair crop of poor quality fruits is formed. These, left to mature, drop from the tree and are commonly affected by Brown Rot—the organism developing in typical manner thereon. Twig-blighting, ascribed to other causes, is at times severe in these trees.

Pears.—Brown Rot is not serious on pears in Australia. Instances of infection are not uncommon in householders' gardens, but of rare occurrence in commercial orchards. The author has on many different occasions isolated the typical *Monilia* from pears that have been damaged by mechanical agencies. Twig-blighting, cankering, or blossom-blighting has not been observed in N.S.W.

Plums.—Both English and Japanese varieties are grown fairly extensively in areas affected by Brown Rot in N.S.W. The losses sustained from Brown Rot are at times severe.

In seasons 1919-20 and 1920-21 the author saw many instances in which the whole crop of several varieties (Lutherborough, Burbank, Angelina, Black Japanese) growing in stone fruit orchards was destroyed. In other cases, while losses in the orchard were moderate, fruit was destroyed before reaching the markets or before being consumed. In 1928 the author inspected an orchard where there were growing 60 aged plum trees (Shiro variety). The trees each bore 10 to 12 cases of fruit and were breaking down with the crop. Owing to a glut in the market the fruit could not be profitably marketed at its correct stage. Before the fruit was harvested, conditions favourable to Brown Rot developed, and the whole crop was destroyed. Many other instances of extensive damage were noted. Twig-blighting occurs, the spurs being killed back, but the effect is neither so noticeable nor so disastrous as it is in peaches or nectarines. Blossom-blighting has been observed in nature on several occasions and induced by inoculation.

Quince.—While this fruit is not grown extensively on a commercial scale in N.S.W. it is very popular with coastal orchardists and householders. The fruit is susceptible to Brown Rot infection, particularly when damaged by Codlin Moth or mechanical agencies. A loss of 20% of fruit is not uncommon, particularly in householders' allotments. Twig-blighting occurs, but does not appear seriously to affect the tree.

The Fungus Causing Brown Rot of Fruits.

(a) In Other Countries.

Wormald (52) states that "it is now recognised that there are at least four different Brown Rot fungi (either species or biologic forms) each of which is responsible for considerable damage to the world's fruit crop".

These are:—

Sclerotinia fructigena.
S. cinerea forma *pruni.*
S. cinerea forma *mali.*
S. fructicola (*S. americana*).

Persoon (34) in 1796 gave to the organism causing Brown Rot the name *Torula fructigena*, but in 1801 (35) changed this to *Monilia fructigena*. This held until Schröter (42) in 1893, on the basis of work done by Woronin (54), but without having seen the perfect stage, named the fungus *Sclerotinia fructigena*. Aderhold and Ruhland (1), in 1905, validated the name.

Bonorden (7) discovered in 1851 a second fungus causing Brown Rot of fruits to which he gave the name *Monilia cinerea*. Schröter (42) assumed that this also was a *Sclerotinia*, but it was not until 1921 when Wormald (50) described the apothecial stage of *Monilia cinerea* (f. *pruni*) that the assumption was proved correct, and the name *S. cinerea* validated. The classic studies of Woronin (53) in 1900 clearly differentiated between the two foregoing species.

Despite this, apparently most pathologists throughout the world used the name *S. fructigena* for the organism causing Brown Rot of fruit. Hence we find Norton (29, 30) in 1902 in America using that name for the fungus we now know to be *S. fructicola* = *S. americana*.

The name *S. fructigena* was used generally in America until Matheny (27), Valleau (46), Conel (11), Bartram (5), and others, working with fresh material, confirmed the claim made in 1905 by Aderhold and Ruhland (1) that the common American Brown Rot fungus was more closely akin to *S. inerea* than to *S. fructigena*. In fact, *Sclerotinia fructigena* has not yet been found in America (52). Thus from about 1914 onwards, we find that throughout

American literature the name given to the common Brown Rot fungus of America was *S. cinerea.*

Wormald (49, 50) in 1919 and subsequently, proved conclusively that there occurred in England both *Sclerotinia fructigena* and *S. cinerea.* He divided the latter into two distinct biologic forms which he designated *S. cinerea* forma *pruni* and *S. cinerea* f. *mali.* He also showed in 1917 (47) that the common American fungus, while closely related morphologically to *S. cinerea,* was culturally distinct. For this fungus, common throughout the American fruit growing regions he later (49, 50) proposed the name *S. cinerea* f. *americana.*

Norton and Ezekiel (32) and Ezekiel (19) in 1924 confirmed Wormald's observations, but considered that the American fungus was sufficiently distinct morphologically to justify specific rank. They proposed the name *S. americana* (Wormald) Norton and Ezekiel (32).

The separation of *S. cinerea* and the common American fungus has been simplified by the recent discovery of the true *S. cinerea* of England and Europe on the Pacific coast of North America. There it has been possible to study the two fungi under identical environmental conditions. (6, 40, 19). It is now accepted that the common American fungus is a species distinct from *S. cinerea.*

While confirming the cultural and morphological differences existing between the common American fungus and *S. cinerea,* (39) Roberts and Dunegan (40) consider that the correct name for the American fungus is *S. fructicola* (Wint.) Rehm.

In the opinion of the author, the evidence adduced by them is sufficient to prove their contention. The first valid name applied to the apothecial stage of the American Brown Rot fungus should be universally adopted when describing that fungus. Throughout this paper, therefore,

the name *S. fructicola* (Wint.) Rehm will be used in preference to *S. americana* (Worm.) Norton and Ezekiel.

Thus apparently within a quarter of a century the same fungus was successively called *Sclerotinia fructigena, S. cinerea, S. americana* and *S. fructicola.* That real confusion existed in the minds of American pathologists is demonstrated by the fact that in 1920 Mr. W. L. Waterhouse, of Sydney University, received from an American University a culture of the American fungus under the name of *Sclerotinia fructigena.* In 1922 Dr. R. J. Noble obtained from the same source the fungus under the name *S. cinerea.*

(b) In Australia.

It is to be expected that a similar state of confusion would exist in Australia. The name *Monilia fructigena* Pers. is used by McAlpine (28) who remarked that the most striking symptom was the rotting of the fruit "with the ash coloured spores produced on the surface" and "Tufts compact, pulvinate often confluent and forming concentric rings". Cobb, 1904 (10), Froggatt, 1908 (21), Johnston, 1910 (25), and Allen, 1912 (2) all used, without discussion, the name *Monilia fructigena,* although Johnston (25) stated, "On the surface there appear more or less concentric areas covered by a greyish substance which . . . is seen to be made up of spores . . . of the fungus". Darnell-Smith (15) in 1915 called attention to the confusion then existing in the literature of the world in the words "There has been some confusion in Europe and America as to the exact species of *Monilia* causing Brown Rot". After tabulating the differences between *Monilia cinerea* and *Monilia fructigena* he decided to retain the name *Monilia fructigena* "for the present" until such time as "pure culture work" following the discovery of the apothecial stage in Australia "had cleared the matter up".

In publications of the Victorian and Queensland Departments of Agriculture the name *Monilia fructigena* has also been used until quite recently, for the Brown Rot fungus.

In 1921 (23) the author discovered the perfect stage of the Brown Rot fungus common in Australia. He compared briefly the strain of *Sclerotinia* obtained from a single ascospore with a type culture of the American Brown Rot fungus, then in the possession of Mr. W. L. Waterhouse, University of Sydney. This type culture, obtained from U.S.A. in 1920, was labelled *Sclerotinia fructigena*. The two fungi were very similar and hence the author reported (23), "Already there are definite indications, however, that the organism producing the apothecium is *Sclerotinia fructigena*". He also stated, ". . . Further studies are in progress".

It soon became evident that neither of the two organisms was *Sclerotinia fructigena*. In 1922 Mr. W. L. Waterhouse wrote to Wormald (52): "Mr. Harrison is now satisfied that the ascigerous strain he has is *S. cinerea*. The culture obtained from America and labelled *S. fructigena* is quite certainly wrongly named". In 1923 the author read a paper before the Pan-Pacific Congress in Sydney. In this paper* he stated: "From a comparison of several New South Wales forms of *Monilia* with one American and three English forms it is possible to say that the organism responsible for Brown Rot and associated troubles in New South Wales is *Sclerotinia cinerea* (Bon.) Schröter". No distinction was made at that time between *S. cinerea* and *S. fructicola* (*S. americana*). From that time the name *S. cinerea* has been used in Departmental publications of Australia for the common Brown Rot organism. The author has been prevented by teaching duties from pre-

* Title only "Brown Rot of Fruits in Australia" in Proc. Pan-Pac. Sci. Congress, 1923, p. 154.

viously publishing the results of further studies mentioned above. Recently an opportunity has occurred of continuing the Brown Rot studies and it is with the object of clearing the stage for further results that this paper is now published.

The Identity of the Australian Brown Rot Fungus.

It can be seen that the first problem to be investigated, in 1921 and subsequently, was that of the correct determination of the species of *Sclerotinia* responsible for Brown Rot in Australia. Two strains, one ascosporous from apricot and the other conidial from apple, were grown on each of the following media:—Maize meal agar, prune juice agar, malt extract agar, potato dextrose agar, on prunes, on pear, apple, potato and quince plugs—five tubes of each being observed at short intervals for four weeks. No difference was noted between the two strains used. A summary, made in April, 1922, of the results is as follows:—

"The characteristic features of the local Brown Rot fungus are (1) mycelial growth is sparse, (2) conidial production is abundant. The tufts are at first grey, but as the conidia mature the colour changes to light fawn and later to a bright fawn. (The colour is between Ridgway's Tilleul-buff and vinaceous buff. Plate 40.) The pustules are small—of the pinhead type—and often so abundant as to be confluent and commonly arranged concentrically. (3) Nigrescence of the medium varies in intensity, but always develops quickly after inoculation."

At that time it was further recorded, "the conidial growth is that of a typical *Sclerotinia* so closely resembling Matheny's description of the American *S. cinerea* as to justify grouping our form with the American form."

These observations and a study of the literature available indicated that our Brown Rot fungus was not *S. fructigena*,

despite the fact that it agreed closely with a culture so labelled. The following steps were taken to prove this:—

Cultures of *Sclerotinia fructigena* and *S. cinerea* were obtained through the courtesy of Mr. W. L. Waterhouse from Dr. Wormald, of Wye, Kent, England. In a series of experiments, both ascosporous and conidial strains of the fungus were compared with these.

A selection of the experiments follows:—

Experiment No. 1.

Prune Inoculation.

Boiling water was poured over prunes which were allowed to soak for 20 hours. The prunes were placed on cotton wool, moistened with distilled water, in the bottom of each of several Erlenmeyer flasks. The flasks were plugged with cotton wool and autoclaved at 15lb. pressure for 20 minutes. This resulted in the cotton wool being saturated with prune extract.

Inoculations were made as under and controls established on 15/4/'22—the inoculum in all cases being derived from fresh cultures on potato plugs.

Flask No. 1—Inoculated with *Monilia fructigena* (England).

" " 2—Inoculated with *S. cinerea* (England).

" " 3—Inoculated with the local Brown Rot fungus (Conidial strain).

" " 4—Inoculated with *Monilia fructigena* and *Sclerotinia cinerea* on opposite sides of each prune.

" " 5—Inoculated with *Monilia fructigena* and the local Brown Rot fungus as in 4.

" " 6—Inoculated with *Sclerotinia cinerea* and the local Brown Rot fungus as in 4.

Detailed observations were made at frequent intervals and final conclusions recorded when the experiment had been in progress 20 days.

A summary of the behaviour of the various organisms is as follows:—

Sclerotinia cinerea.—A slowly formed white cobweb-like mycelial mat and ashy grey small conidial tufts were produced in abundance on the older preparations. Nigrescence absent.

Monilia fructigena.—Much more vigorous in growth than *S. cinerea.* A great mass of aerial hyphae, at first loose, then later dense, was produced over the surface of the prunes and cotton wool. Conidial tufts, large, buff-coloured and dome-shaped, were abundantly developed on all the prunes. Nigrescence absent.

Local fungus.—This spread very rapidly and was very distinct from the former two in the following particulars: (1) it showed extreme reduction of mycelial growth, (2) it produced abundance of conidial tufts—the whole surface of affected areas being covered with small tufts, which were almost confluent and arranged concentrically, (3) it induced the production of excessive nigrescence in the medium, the prunes and surrounding cotton wool being turned jet black.

Experiment No. 2.

Sub-cultures.

The three fungi—*Monilia fructigena, Sclerotinia cinerea* and the local Brown Rot organism (ascosporous strain)—were grown on each of the following media:—Prune juice agar, prune, pear, apple.

The inoculum in each case was obtained from fresh cultures on sterile potato plugs. Duplicate inoculations were made in April, 1922. A summary of the notes recorded is given on page 119.

Monilia fructigena. (F)	*Sclerotinia cinerea.* (Y)	*Local fungus.* (M)
Prune Juice Agar.—White mycelial growth, surface and sub-surface. No conidial tufts. No nigrescence.	A much slower and less vigorous mycelial growth closely appressed to surface, and more sub-surface than F. No nigrescence. At end of 12 days some ash-grey conidial tufts.	Fructifications abundant, grey then fawn. Nigrescence of sub-strata marked.
Prune.—White dense mycelial growth. Some aerial tufts. Some fructification about point of inoculum, none elsewhere. No nigrescence.	A sparse white mycelial mat over surface of prune. Some short grey aerial tufts. No nigrescence.	Abundance of fawn pustules over darkened area. No mycelial mat. Nigrescence present.
Pear.—At first delicate then more vigorous and dense mycelial growth. Few conidia around point of inoculum. No nigrescence.	Very little mycelial growth, but ash-grey conidial tufts abundant about point of inoculum. No nigrescence.	Conidial production very abundant. Fawn pustules over a darkened sub-strata. Slight mycelial mat.
Apple.—Very vigorous, white, felt-like, aerial, mycelial growth with no conidia produced in 12 days. No nigrescence.	Little mycelial growth, no surface web. Fruiting abundant. Conidial tufts ash-grey, but not pustular. No nigrescence.	Apple plug completely covered with very abundant organised fawn pustules. Sparse mycelial growth.

Experiment No. 3.

Inoculation of Fresh Apples.

Unblemished Cleopatra apples were surface sterilised by wiping over with cotton wool saturated with 95% alcohol, then rinsed in freshly distilled water.

With a sterile scalpel, cuts were made in the sides of the apples and into these was placed the inoculum which was obtained from pure cultures of each organism growing on prunes in flasks.

The apples were inoculated as follows on 29/4/'22:—

Apple 1—Local Brown Rot fungus (Conidial strain) (M) on both sides.

„ 2—*Monilia fructigena* (F) (England) on both sides.

„ 3—*Sclerotinia cinerea* (Y) (England) on both sides.

„ 4—*S. cinerea* (Y) and *Monilia fructigena* (F) on opposite sides.

„ 5—*S. cinerea* (Y) and local fungus (M) on opposite sides.

„ 6—Local fungus (M) and *Monilia fructigena* (F) on opposite sides.

Controls were established.

Detailed observations of the rots were made at close intervals until 12/5/'22 when the experiment was discontinued.

The controls at this time were still healthy.

A summary of the observations follows:—

(1) The local Brown Rot fungus produced a *black* rot with small greyish to fawn pustules produced along the cut surface of the fruit and to a small extent over the rotted areas (Figs. b. and 3, Plate 4).

ERRATA.

On Page 120, last line, for Figs. b and 3, Plate 4, read Figs. b and c, Plate VIII.

On Page 121, 5th line, for Plate 4 read Plate VIII.

(2) *Monilia fructigena* produced a more rapid *brown* rot with abundant large buff-coloured dome-shaped pustules arranged in zones all over the surface. Some nigrescence later (Fig. b., Plate 4).

(3) *Sclerotinia cinerea* produced the slowest *brown* rot, with ash-grey conidial tufts along the cut surface, but no nigrescence.

Experiment No. 4.

Fresh Apples.

This experiment varied only from No. 3 in that each of the three fungi:—

Sclerotinia cinerea (England) (Y)
Monilia fructigena (England) (F)
Local Brown Rot organism (M)

was inoculated into each of three apples at approximately equal distances around the girth.

Controls were established and frequent observations made.

It was hoped by this means to reduce to a minimum the influence of varying environmental conditions.

The three fungi behaved as in the previous experiment. They are vividly distinct when grown alongside one another on the same apple.

Experiment No. 5.

Tomato Inoculation.

The tomatoes selected were firm, red and unblemished. They were surface sterilised by bathing in alcohol and washing in distilled water.

They were inoculated by inserting loops of conidia into cuts made in the surface. The inoculum was obtained from fresh potato plugs. Two tomatoes were inoculated with the local Brown Rot organism (M), two with *Monilia*

fructigena (F) and two with *Sclerotinia cinerea* (Y). Controls were established.

Detailed observations of each tomato were made at close intervals and the following final conclusions drawn:—

(1) All three strains of organisms will produce a firm rot in tomatoes. In all cases this rot is brown at first. The rot caused by the local organism finally turns black, but that caused by the other two remains brown.

(2) All three strains produce, on the tomato, the fruiting bodies typical of the strain. The local organism (M) produced abundance of fawn-grey pustules over a dark surface. There was no surface mycelial growth. *Monilia fructigena* (F) produces abundance of large buff pustules accompanied by a mass of aerial hyphae. *Sclerotinia cinerea* (Y) produces the distinct ash-grey conidial tufts accompanied by a fine mycelial mat over the infected area.

Experiment No. 6.

Persimmon Inoculation.

Persimmons (*Diospyros kaki* var.), just ready to eat, were sterilised by bathing in 95% alcohol and washing in distilled water. With sterile scalpels the letters M, F and Y were made in the sides of the sterilised persimmons and into the cuts were inserted loops of conidia taken from fresh cultures on prunes.

The persimmons were inoculated as follows:—

(1) both sides with the local organism (M);

(2) both sides with *Monilia fructigena* (F);

(3) both sides with *Sclerotinia cinerea* (Y);

(4) opposite sides with the local organism (M) and *Monilia fructigena* (F);

(5) opposite sides with the local organism (M) and *Sclerotinia cinerea* (Y);

(6) opposite sides with *Monilia fructigena* (F) and *Sclerotinia cinerea* (Y).

The inoculations were performed and controls established on 18th May, 1922. Detailed observations were made periodically.

The following briefly summarises the results:—

All three strains used will infect and grow on ripe persimmon. The rate of growth is extremely slow. Each strain fruits abundantly on this medium.

(1) The local organism (M) fruited typically. The conidial tufts were small, fawn coloured and very abundant. Extreme nigrescence was produced.

(2) *Monilia fructigena* (F) produced an abundance of large, loosely packed, dome-shaped, light buff pustules. A much slower nigrescence was produced. The firm nature of the rot produced is striking, for, in many cases, the uninfected part of the fruit and the controls were shrinking while the infected part retained its shape.

(3) *Sclerotinia cinerea* (Y) produced no nigrescence and was much slower in rotting the fruit. Ash-grey tufts were produced in abundance along the cut surface and over the infected area.

It can be seen that the foregoing experiments established definitely that the common Brown Rot organism found in Australia was neither *Sclerotinia fructigena* (Pers.) Schröt. nor *S. cinerea* (Bon.) Schröt. (English form).

Its behaviour in the inoculation experiments and its growth in culture indicated that it was identical with the American organism (*S. fructicola*).

A series of experiments was conducted to determine this point. A selection of those experiments follows:—

Experiment No. 7.

Quince Inoculation.

Quinces, of approximately the same stage of maturity and as free from blemishes as possible, were selected.

They were surface sterilised by bathing in 95% alcohol and washed in freshly distilled water. Twenty-four were then inoculated with the local Brown Rot organism (Ascospore strain).

Twenty-four with the American organism, *S. fructicola.*

Twenty-four with *Monilia fructigena* from Wye, England.

Twenty-four with *Sclerotinia cinerea* from the same source.

The inoculum was obtained from 10 days old cultures on potato plugs and consisted of a loop of conidia in each case.

A wedge of quince was cut out with a sterilised scalpel and the inoculum placed beneath this wedge—the wedge being lifted momentarily with a sterilised needle. Two inoculations were made on each quince. When inoculated, the quinces were placed in a saturated atmosphere in the glasshouse.

The inoculations were performed and controls established on 22nd May, 1922.

Detailed records of the progress of the rots were kept. The following summarises the information thus obtained:

All the inoculations were effective, resulting in typical brown rot lesions.

Local Sclerotinia.

The rot developed quickly, and nigrescence was very marked, developing rapidly. Grey to fawn conidial tufts were very abundant. These were mostly small, and at times confluent, in some cases arranged in well defined

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On Page 125, 2nd line, for Plate 4 read Plate VIII.
Same Page, 17th line, for Plate 4 Fig. a, read Plate VIII. Fig a.

zones. They appeared very soon after rotting commenced. (Plate 4, Figs. d.e.)

American Sclerotinia.

This was inseparable under the conditions of the experiment from the local *Sclerotinia*.

Sclerotinia cinerea (England).

The rot was not so rapid as above. Nigrescence was absent, the rotted fruits remained entirely brown. Tufts of aerial hyphae developed some time after the rot commenced, but no conidia were produced until the rot was well advanced. The sparse conidial tufts were ash-grey.

Monilia fructigena (England).

The rot developed very rapidly, but nigrescence was not so intense as that produced by the Australian *Sclerotinia*. Very large aerial hyphal masses were produced. These soon were covered with the buff coloured conidial tufts. (Plate 4, Fig. a.) The nature of the mummified fruit produced is interesting. Those of the Australian and American strains were hard, dense black and much shrivelled—deeply furrowed and ridged. Those of both *Sclerotinia cinerea* (England), and *Monilia fructigena* were not nearly so shrunken—the outline of the quince being maintained. The brown colour of the *S. cinerea* mummy readily separated it from that of *M. fructigena*, which was black.

Experiment No. 8.

Blossom Blight.

In September of 1922, an experiment was conducted to determine the relative virulence of the Australian strains of the Brown Rot organism and the American *Sclerotinia*, in attacking plum blossoms.

Conidia for the inoculations were obtained from young cultures on potato plugs. Two strains of the local organism

(one ascosporous and the other conidial), and one American strain were used. Three methods of inoculation were employed.

(1) *Loop.*—In this method a sterile platinum loop, after being dipped in sterile water, was brought into contact with tufts of conidia, and the resultant loop of spores transferred to the stigma of the flower.

(2) *Prick.*—In this method the ovary was pricked with a sterile needle, which was placed in sterile water, touched on conidial tufts and inserted into the opening previously made at base of ovary.

(3) *Spray.*—10 ccs. of sterile water were added to a tube containing a heavily sporulating plug of potato, and the resultant spore suspension transferred to a small bottle containing 40 ccs. sterile distilled water. A scent spray previously sterilised by immersion in 90 per cent. alcohol was used to convey the spores to blossoms.

The clumps of flowers were selected as far apart as possible to offset the danger of contamination. Immediately after inoculation, each clump was enclosed in waxed translucent paper bags, and a label attached to the base of the clump.

All possible care was taken to perform the inoculations in as aseptic a condition as possible. Controls were established.

Detailed observations were made periodically.

Briefly, the results were as follows:—

(1) *Loop inoculation.*

All three strains caused blossom blighting. No difference could be noted between the strains in their ultimate effect, although the Australian strains were more rapid in their action. Conidia were produced on rotted blossoms which were browned. From 80 to 100 per cent. of the flowers in various groups became infected.

(2) *Prick inoculation.*

The same effect was produced in this case as in that of the Loop inoculation, except that the percentage of infection was higher. Conidial production was variable.

(3) *Spray inoculation.*

Infection in this instance was from 60 to 80 per cent., but possessed the same features as those of Loop inoculation.

Controls in all cases were healthy, setting fruit in a normal manner.

Experiment No. 9.

Apple Inoculation.

Trivett Seedling apples carefully selected as being of approximately the same state of maturity were picked and very carefully handled to avoid bruising. These were surface sterilised with 95 per cent. alcohol and rinsed in distilled water.

The apples were inoculated by inserting conidia beneath a wedge of apple cut out with a sterile scalpel and lifted momentarily with a sterile needle. The inoculum in each case was obtained from fresh cultures on sterile potato plugs.

Two strains of the Brown Rot organism were used, e.g.:

(1) The American *Sclerotinia.*

(2) The Australian *Sclerotinia.*—An ascospore strain obtained in September, 1922, from an apothecium arising from apple mummies.

With each strain twenty-four apples were inoculated and placed in a saturated atmosphere in the glasshouse. Controls were established. Observations were made at close intervals until the infected apples were completely rotted and mummified.

A summary of the result is as follows:—

(1) *American Sclerotinia.*—In every instance inoculation was successful, and the apples were completely rotted in 8 days. The rot was firm and at first brown. Nigrescence did not develop to any extent until the fruit was completely rotted. Small, rounded, grey to fawn, well defined pustules were fairly abundant over the rotted areas. At times these were confluent, especially around the margins of the wedges removed for the purposes of inoculation. As the apples mummified they became black and the conidial tufts assumed a bright fawn colour.

(2) *Australian Sclerotinia.*—The local strain differed only from the above in the greater abundance of conidial tufts. These were arranged in concentric rings over the whole surface of the rotted fruits.

Discussion.

Concurrently with the experiments described above, the Australian and American strains of *Sclerotinia* and many local Monilia strains were sub-cultured some hundreds of times on different media.

Apothecia of the Australian organism were also available in large quantities, and the author was enabled to obtain measurements of asci and ascospores.

As a result of the correlation of all available data, the author was convinced that the Brown Rot organisms common in America and Australia were identical.

At that time (1922 and 1923), the author considered that while American pathologists recognised certain differences between the American form and *Sclerotinia cinerea*, the feeling was against the use of the term, *S. cinerea* forma *americana,* as throughout the American literature the name *S. cinerea* was retained. Even in 1924 Roberts and Dunegan (39), after careful consideration of

all available information, preferred to adhere to the name *Sclerotinia cinerea* (Bon.) Schröt, for the American Brown Rot fungus.

Consequently, in 1923, the author felt justified in stating "The organism responsible for 'Brown Rot' and associated troubles in New South Wales (Australia), is *Sclerotinia cinerea* (Bon.) Schröt."

At a meeting of the Pan-Pacific Science Congress in Sydney that year, he demonstrated the close connection existing between the Australian and American *Sclerotinia*, and the dissimilarity of both these strains to *Sclerotinia cinerea* and *Sclerotinia fructigena* of England.

Confirmation of the identity of the Brown Rot fungi common in America and in Australia has recently been given by Wormald (52). He stated "The Brown Rot fungus generally distributed in the fruit-growing regions of Australia would appear, therefore, to be *S. americana.*" Further, through the courtesy of Mr. W. L. Waterhouse, the author has been enabled this year (1928), to study Ezekiel's type cultures of the American fungus.

A series of comparative inoculations has been made. The observations made leave no question of the co-specific nature of the American and Australian Brown Rot fungi.

The position in regard to the nomenclature of the Australian fungus has changed since 1923. Pathologists are now agreed that the common American Brown Rot fungus is a species distinct from *Sclerotinia cinerea* (Bon.) Schröt. As indicated elsewhere, the author considers that the correct name to apply to the former species is *S. fructicola* (Wint.) Rehm.

To this species, therefore, must now be referred the Brown Rot fungus common in Australia.

In fact, it would appear that at present *S. fructicola* is the only species of Brown Rot fungi to have gained entrance to Australia.

The author has obtained large numbers of specimens of "Brown Rot" from Queensland, Victoria, Tasmania and New South Wales. Thousands of instances of natural infection (both fruit and twig), have been studied in the field. A large number of cultures have been obtained from the full range of hosts and from fruit districts having widely dissimilar climatic conditions.

In no instance up to July, 1928, has the author found *S. fructigena* or *S. cinerea* in Australia.

THE APOTHECIAL STAGE OF BROWN ROT FUNGI

Apparently the first apothecia of the Brown Rot fungi were found by Rau "On peach mummies at Bethelehem, Pennsylvania, U.S.A., in 1883," but "the identity of this material with the ascogenous stage of the American Brown Rot fungus" (20) common at present, was not established until 1924 (39), although Pollock (36) in 1909 had indicated that this was so.

Roberts and Dunegan (39) conclude: "It therefore seems certain that in 1883 Rau collected and Winter described the species of *Sclerotinia* which Norton in 1902 showed to be the ascogenous stage of our common Brown Rot fungus."

Norton (29, 30) in 1902 found numbers of apothecia in a Maryland orchard, U.S.A. Since that time in U.S.A. the material has been recorded at intervals arising from mummies of apricots, cherries, nectarines, peaches and plums. Apothecia are apparently common in America, and at times produced in large quantities.

In Europe, in 1905, Aderhold and Ruhland (1) found apothecia which they showed to be the perfect stage of

Monilia fructigena. The material has been found since at intervals, but apparently is not nearly so common nor so abundant as that of *Sclerotinia fructicola.* Apothecia of *S. fructigena* have not yet been reported from England.

In England, however, in 1921, Wormald (50) found apothecia arising from mummified plums. These he proved to be the perfect stage of *Monilia cinerea* (Bon.). Apparently these are neither common nor abundant, foı Wormald (52) stated, "Although the ascigerous stage of *S. americana* has been found on many occasions and in great quantity, this stage of *Sclerotinia cinerea* has been found very rarely."

In New Zealand apothecia of the Brown Rot organism there present were discovered in 1922 by Cunningham. They are apparently abundant.

Apothecia, at times in large quantities, have been found in New South Wales, Australia, in 1921, 1922, 1923, and 1924.

The Apothecial Stage in Australia.

Occurrence

1921.

In November, 1921 (23) the author recorded the discovery, on September 22, of two apothecia arising from mummified apricots in an orchard near Sydney, N.S.W.

He showed that this was the perfect stage of our common Brown Rot fungus. On that occasion, time did not allow of searches for further specimens being made.

The summers of 1919-20 and 1920-21 were exceptionally favourable to Brown Rot incidence on the Coast. Consequently Brown Rot mummies of most stone fruits were abundant in orchards during springs of 1921, 1922 and subsequently.

1922.

Between 11th and 16th September, 1922, showery weather conditions prevailed, approximately 2 inches of rain being recorded in the period. The following days were warm with a heavy fog in the early mornings over the valley mentioned below.

On 17th September, 1922, a search was made for apothecia in a neglected stone-fruit orchard at Beecroft, near Sydney, N.S.W. The orchard was approximately 3 miles distant from where apothecia were found in 1921.

The orchard nestled in a valley with heavy timber on northern and western sides. It was thus protected from the effect of drying westerly winds.

Large numbers of apothecia, developing from plum mummies, were found. A particularly favoured spot was on the southern side of a large packing shed. Apparently in this spot the mummies were protected from the drying effects of the afternoon sun.

It was noticed that the apothecia arose from mummies in all positions. An apparent necessity was that the mummies be at least partly buried in the soil, and in such a situation as to assure a slow drying after rain.

Apothecia arise from the underside of the Sclerotium. This may be a mere fragment or a complete mummified fruit, with seed capable of germination. The stipe curves to reach the surface when the cups slowly expand. On one Sclerotium there were counted 57 stipes, each tipped with an immature apothecium.

The method of expansion and conditions governing production of the apothecia are treated at length by Norton *et alia* (31) and by Cunningham (13, 14).

On 20th September, 1922, many apothecia were found in the same orchard arising from mummies of peach and plum.

On this occasion photographs of the apothecia *in situ* were taken by Mr. W. L. Waterhouse (Fig. f, Plate V; Figs. a and b, Plate VI).

The neglected conditions of the orchard, typical, at that time, of many within a short distance of Sydney, is shown in Fig. d, Plate VI.

At the University on 19th September, 1922, apothecia were found arising from mummies of apricots, peaches, plums and apples. These mummified fruits had been collected from orchards near Sydney during the summer of 1921-22.

These fruits had been partly covered with soil in shallow earthenware dishes (seed pans), and exposed to normal climatic conditions since that time.

Apothecia of *S. aestivalis* (Pollock) on the date mentioned were also present on many of the mummified fruits. A paper dealing with *S. aestivalis* (Pollock), will be published later.

Time was not available in which to make a search for the apothecia in other localities or districts.

1923.

With the beginning of the month of September rain began and continued showery until the morning of 7th, approximately 2 inches rain being reported.

On 9th September an attempt was made to find apothecia in the same orchard in which they had been so abundant in 1922. At this time, however, only a few mature apothecia were available, the majority being in the "stipe" stage.

The next four days were warm "spring" days, with some winds and rapid drying conditions unfavourable to apothecial development.

In pockets of soil, and where mummies were protected by weeds or by the large packing shed previously mentioned, mature apothecia were abundant on 13th September.

These apothecia arose from mummies which had not been disturbed for at least 2 years. In positions other than those mentioned the apothecia did not mature—no progress had been made since 9th September.

1924.

This year September rains were late. The beginning of the month was dry, but on 22nd and 23rd approximately an inch of rain fell. An opportunity of searching for apothecia did not occur until 28th September, when on the southern side of the packing shed, in the same position as in 1922 and 1923, many mature and shrivelled specimens were obtained.

It is interesting to note that in this year the fruit had set in the orchard where the search was made, before the rains necessary for apothecial production were received. In the previous years, however, blossoming and apothecial production were coincident. Norton *et al.* (31) discussed the production range of apothecia, and suggested that apothecial production may also be correlated with seed germination. The evidence submitted by them certainly supports this suggestion. The author has found apothecia arising from Sclerotia, which enclosed germinating seed (Fig. a, Plate V), but this state of affairs was exceptional. In December, 1921, apothecia of *Sclerotinia aestivalis* Pollock were very abundant. In many cases these arose from mummies from which seedlings were appearing. At that time, apothecia of *S. fructicola* could not be found. It would appear, therefore, that, in New South Wales, there is not a very definite correlation between the time of apothecial production and of germination of seeds.

1925, 1926, and 1927.

Apothecia were not observed during these three years. Other work prevented a search being made for them. A study of the rainfall records shows, however, that 1925 and 1927 were too dry at the crucial period for apothecia to be developed. In 1926 sufficient rain fell towards the end of September to make apothecial production possible, and apothecia were probably produced in that year.

Under the conditions prevailing in the vicinity of Sydney, New South Wales, it would seem that apothecia are fairly common in the spring, providing that mummified fruits are left undisturbed for several months prior to heavy rain and provided that rapid drying out of soil and/or mummy is prevented by natural or artificial means.

The author's experience is that apothecia are absent from well cultivated orchards. During the period 1922-24, a careful, but fruitless, search was made for apothecia in orchards in which mummified fruits were abundant, but which had been tilled during the winter.

In each of the years 1922, 1923, and 1924, at the time apothecia were collected, natural cases of "blossom blight" in plum trees were noticed. Apothecia (Figs. g and h, Pl. V) were found arising from mummies produced from newly-formed fruits. Bunches of immature fruits infected with Brown Rot have been collected (Fig. c, Pl. VI). This illustrates that the fungus may infect immature fruit and there multiply.

The Apothecia.

The general shape and manner of production of the apothecia is illustrated by photographs in Pl. V. These agree closely with published photographs of the apothecia found in America and with descriptions by Norton (30, 31), and others.

In view of this, a full description of the apothecia found in Australia is unnecessary. The shape was usually crateriform at maturity, but sometimes flattened or slightly recurved; the margin was sometimes broken.

The length of the stipe measured from base of the cup to the sclerotium ranged up to 37 mm. The width of cup varied tremendously—the largest measured 23 mm. in diameter.

Rhizoids were common and especially noticeable in young specimens.

Asci.

These agreed closely in shape with descriptions published by Norton *et al.* (31), Matheny (27), Reade (38), Wormald (50), and others.

Camera lucida drawings were made (Fig. a, Pl. VII) and measurements obtained. The following table will show variation in size determined by various authors, all of whom used fresh material.

Table 1.—Size of Asci and Ascospores of S. Fructicola and S. Cinerea.

Author.	Organism.	Asci in Microns.	Ascospores in Microns.
1. Bartram (5)..	*S. fructicola.*	150.4 x 8.8.	10.1 x 7.1.
2. Valleau (46)	*S. fructicola.*	102-166 x 3.5-5.7.	5.6-8.9 x 2.9-3.8.
3. Matheny (27)	*S. fructicola.* (Peach)	135-190 x 6.9-10.5, mostly 163 x 8.9.	10.5-14.5 x 5.2-7.5, mostly 12.5 x 6.2.
4. Matheny (27)	*S. fructicola.* (Plum)	135-173 x 6.8-10.8, mostly 151 x 9.4.	9.3-14.2 x 5-7.4, mostly 11.8 x 6.3.
5. Pollock (36)..	*S. fructicola.*	130-179 x 9.2-11.5.	11.4-14.4 x 5.7.
6. Jehle (24) ..	*S. fructicola.*	136-188 x 7.8-10.	10.6 x 5.8.
7. Wormald (52)	*S. cinerea.*	172 x 9.975.	12.5 x 6 2.
8. Harrison .... (present author)	Australian *Sclerotinia* from plum, Beecroft, Sept. 1922, 100 measured.	116-190. Av. 155 x 10.	10.5-16 3 x 5 75-8.2. Av. 12.8 x 6.9

The table shows also how well the Australian *Sclerotinia* agrees with the American *Sclerotinia fructicola.*

Ascospores.

The plates and descriptions given by Reade (38), Matheny (27), Norton (30), and Wormald (50), amply cover


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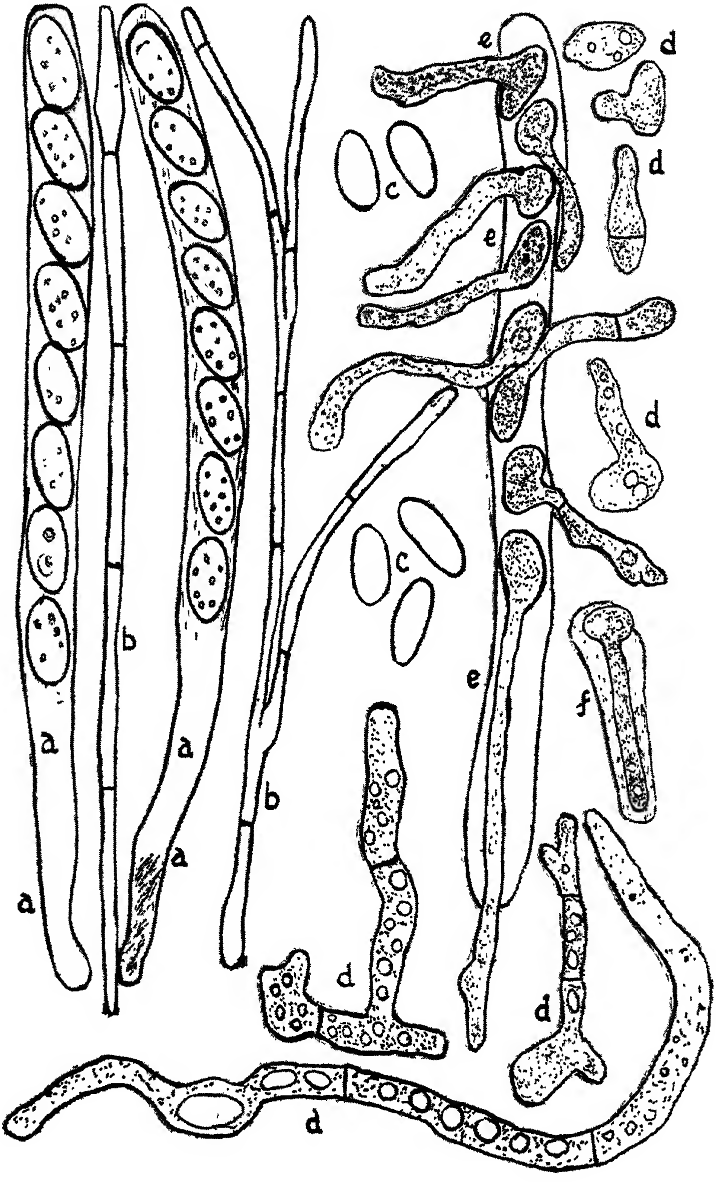

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the details of shape and arrangement within the ascus of these spores.

The size of spores is given in above table (No. 1). Didymous spores rarely occurred. All spores were surrounded by a gelatinous sheath. Camera lucida drawings of spores are given (Figs. a, c, Plate VII).

Germination of the Ascospores may take place within the ascus (Fig. e, Pl. VII) or upon the moist surface of the apothecium.

It may occur in distilled water within 2 hours. The germ tube is usually pushed out from the side and nearer one end than the other. The germ tubes are usually straight for a considerable distance (Fig. d, Pl. VII).

Paraphyses were found to be identical with descriptions published by Reade (38), Matheny (27), and Wormald (50).

The size was found to be 118-200 μ x 2.32-4.65 μ with an average size of 159 x 2.5 μ (Fig. b, Pl. VII).

The Monilia Stage.

Conidia.

As stated previously in this paper, the conidia agree closely in manner of production, size and colour of tufts, etc., with those of *Sclerotinia fructicola* (Figs. c, Plate VII; Figs. e, d, Plate VIII).

Measurements made in 1922 are as follows:—

Lot 1.—From mature tufts on infected peach.

Range: 10.9 to 21.7 μ x 6.7 to 14.9 μ.

Average: 15.9 μ x 10.2 μ.

Lot 2.—From potato plug culture of single spore strain isolated from Trivett Seedling apple.

Range: 10 μ to 20 μ x 6.6 μ to 14.9 μ.

Average: 14.3 μ x 9.7 μ.

Lot 3.—From Quince. Strain obtained from single ascospore from Apricot, 1921.

Range: 11.5 to 19.2 μ x 9.6 to 13.4 μ.

Average: 15.9 μ x 9.7 μ.

In all cases 100 spores were measured in distilled water. The range given applies only to the spores measured.

The following table gives a selection of conidial measurements of *S. fructicola* and *S. cinerea* published by various authors.

Table 2.—Size of Conidia.

Author.	Source of Material and Fungus.	Size in Microns.
Matheny.	*S. fructicola.* Average of large number of measurements from various hosts.	14.7 x 9.9.
Ezekiel.	*S. fructicola.* (S. americana s 22.)	14.5 x 10.8.
	S. fructicola. (S. americana s 45.)	14.9 x 10 6.
Reade.	*S. fructicola.*	mostly 17 x 11.
Wormald.	*S. fructicola* on Peach from Ontario.	16.5 x 12.2.
Wormald.	*S. cinerea.* Winter conidia General	11.5 x 8.
	S. cinerea. Summer conidia Average.	18 x 13.
Saccardo.	*S. cinerea*	15-17 x 10-12.

It would appear that while it is recognised that the conidia of *S. fructigena* are uniformly larger than those of both *S. fructicola* and *S. cinerea,* conidial size in itself is of little taxonomic value in separating *S. cinerea* from *S. fructicola* or in separating the various physiologic forms of *S. fructicola.* The range of size quoted by various authors for conidia of *S. fructicola* is so great as to include both summer and winter conidia of *S. cinerea.*

The figures given for the size of conidia of the Australian organism, however, agree well with the general average size of the conidia of *S. fructicola.*

Disjunctors are absent. Under certain conditions it is possible for some conidia in a chain to be separated from the next ones by a small platform of tissue. This may be due to the formation of two abstricting walls instead of one. This state of affairs is quite exceptional.

Germination of Conidia.

Conidia germinate very quickly in presence of moisture. In most weather sporelings are often abundant over the surface of infested fruits. They may even germinate before being abstricted from the chains.

Wormald (47) and Ezekiel (19) have noted that the conidia of *S. fructicola* germinate in a manner quite distinct from those of *S. cinerea.* The former fungus produces long straight sparsely branched large celled germ tubes. The latter germinates to give a much branched crooked germ tube with small cells.

Conidia from a large number of cultures of the Australian organism were germinated in the manner used by Ezekiel (19). At the same time conidia of *S. cinerea* from England, and of the typical American fungus, were germinated under identical conditions. Cultures of the latter fungus were obtained from Mr. W. L. Waterhouse, who had received them from Dr. W. N. Ezekiel, under the label *S. americana*, form 1 (S. 22), and so on.

The main features noted by Wormald and by Ezekiel were confirmed. Germination from both ends of the conidium are not uncommon. One germ tube usually precedes the other by a few hours. Representative germinations are depicted in Plate IX.

Microconidia were abundant in many cultures. They were circular and highly refractive, 2.5-3.4 microns in diameter.

Apothecia from Apple.

Although Brown Rot caused by *Sclerotinia fructicola* is not uncommon on apples in America, it would appear that the apothecia of that fungus has never been authentically recorded arising from mummified apples.

Norton *et al.* (31) state, "Demaree (17) in 1912 described a *Sclerotinia* on Maryland apples, which may be *Sclerotinia aestivalis* Pollock (37);" and later, in the same bulletin, state, "Although the Brown Rot is frequent on certain summer varieties of apple, *Sclerotinia apothecia* are rare on apple mummies. In addition to Demaree's *Sclerotinia* noted early in this bulletin, apothecia doubtfully associated with apple, have been found a few times in Maryland apple orchards."

Towards the end of the summer, season 1921-22, the author collected from an orchard at Pennant Hills, near Sydney, N.S.W., mummified fruits of apple—Trivett Seedling variety. The author had witnessed in the seasons, 1919-20 and 1920-21, the progress of the rot in the fruits of this variety and had obtained therefrom typical *Monilia* cultures. In many cases the mummified fruits when collected were bearing the small fawn-coloured spore masses so typical of the local *Monilia.* Other mummies when collected from the ground beneath the same tree were producing apothecia of *S. aestivalis.*

These mummies were placed in large open earthenware dishes (Seed pans), partly covered with soil and exposed to normal climatic conditions at the University.

On 19th September, 1922, apothecia were found arising from some of the mummified fruits. These consisted of the small flattened apothecia of *S. aestivalis* and of the larger crateriform apothecia similar to but smaller than those usual for *S. fructicola.* Photographs were obtained (Fig. i, Plate V).

Microscopic study of the Asci and ascospores showed that the latter apothecia were undoubtedly those of *S. fructicola.*

Single ascospore isolations resulted in a typical Monilia growth. Under the accession number 200 it has been in culture since that time.

An extensive series of observations made of its behaviour on fruits and on artificial culture media did not enable the author to separate this ascosporic strain from those derived from apothecia of plum and apricot.

Moreover, cultures of two strains of *Sclerotinia* derived from apple and plum apothecia respectively were sent to Dr. Wormald by Mr. W. L. Waterhouse. After an investigation, Dr. Wormald decided that the two cultures sent to him were identical and, therefore, discarded the one which had been obtained from plum. It is, therefore, the culture from apple which has been considered typical of the Brown Rot fungus present in Australia.

The author, therefore, considers that here is a valid case of the apothecia of *Sclerotinia fructicola* arising from mummified fruits of the apple.

The specimens have been preserved and are still in good condition.

Brown Rot in New Zealand.

Australia and New Zealand are vitally concerned with each other's fruit diseases. Their relative proximity and their isolation from other fruit-growing centres make it necessary for each to know exactly what diseases are present and to define the causal organisms.

Brown Rot has been present in New Zealand for at least 23 years. Heavy losses to fruitgrowers have occurred through the destruction of both stone and pome fruits. In view of this, and of the fact that the climatic conditions of New Zealand somewhat approximate those prevailing in England, it is of extreme importance to Australia that the species of fungus causing Brown Rot in New Zealand should be correctly determined.

The author therefore wishes to present the following statement:—

Cunningham in 1922 (13) and in 1915 (14), from a consideration of both the *Monilia* and *Sclerotinia* stages, retained the name of *Sclerotinia cinerea* (Bon.) Schröt for the organism responsible for Brown Rot in New Zealand. In the latter publication (14) *Sclerotinia americana* (Norton and Ezekiel) is given as a synonym. As far as the author is aware, there have been published no taxonomic or cultural details dealing with the New Zealand Brown Rot organism. Wormald (52), however, obtained cultures from apricot, peach and plum mummies, and from peach twigs sent from New Zealand. Studies showed that "in every case these were *Sclerotinia americana*." He concluded, "This species is probably, therefore, the fungus responsible for the greater part, if not the whole, of the Brown Rot damage in New Zealand."

The Sclerotinia Stage.—In 1922 the author was enabled, through the courtesy of Mr. W. L. Waterhouse, to examine peach mummies bearing apothecia, received by the latter from Dr. K. N. Curtis, of Cawthron Institute, New Zealand. These apothecia were collected at Stoke, near Wellington, New Zealand, on September 29, 1922, and preserved in 70 per cent. alcohol. They were, in shape, colour, and size, identical with those collected in New South Wales during 1921 and 1922. Measurements of Asci were made in October, 1922. Portions of apothecia were taken through a range of alcohols to distilled water, in which the material was teased out and lightly tinted with Gentian Violet.

All the measurements obtained were less than those obtained from fresh apothecia, but a study of the following table appears to indicate that preserved material is shrunken.

All authors mentioned in the table used preserved material. The difference in the treatment given that material would possibly be sufficient to explain the variation in measurements recorded.

Table 3.—Size of Asci of Sclerotinia Fructicola Obtained by Using Preserved Material.

Author and Date.	Organism and Source of Material.	Size of Asci in Microns.
Aderhold and Ruhland (1905)	*Sclerotinia fructicola* from Norton, Kansas, U.S.A.	89.3-107.6 x 5.9-6.8.
Winter (1883)	*Sclerotinia fructicola* (Ciboria fructicola) from Rau, Pennsylvania, U.S.A.	130-160 x 8-8.5.
Dunegan (1924)	*Sclerotinia fructicola* (Winter's type material).	117-161 x 5.7-9.5.
Harrison (1922)	*Sclerotinia fructicola* from Wellington, N.Z.	135.6 x 7.8.

The photos and descriptions of the New Zealand apothecia, published by Cunningham (13, 14), could well apply to the apothecia so abundant in America and in Australia. The very abundance of the apothecia in New Zealand is a further indication of the identity of the fungus present there with that present in America and Australia.

The Monilia Stage.

Cunningham (14), in support of his claim that apples and pears are not natural hosts for the fungus, wrote, "Brown Rot appears in the flesh . . . . and gradually spreads until, in time, the whole fruit becomes infected, when it turns quick black. Few or no tufts of conidia are produced on the surface of such fruits."

Earlier in the present paper the author summarised the results of an apple inoculation experiment as follows: "The local *Monilia* produced a *black* rot with small greyish to fawn pustules produced along the cut surface of the fruit and, to a small extent, over the rotted areas;" while in the same experiment *S. cinerea* produced "a brown rot." In fact, nigrescence seems always to be absent from media inoculated with *Sclerotinia cinerea.*

It would seem, therefore, that from the last mentioned statement of Cunningham, it is possible to conclude three things, viz., (1) the New Zealand Brown Rot fungus is not *S. fructigena*, (2) it is not *S. cinerea*, (3) it is apparently, therefore, *S. fructicola*.

Cunningham (14) describes the "small scattered grey tufts" so typical of the last fungus, and a photograph of conidial masses is published.

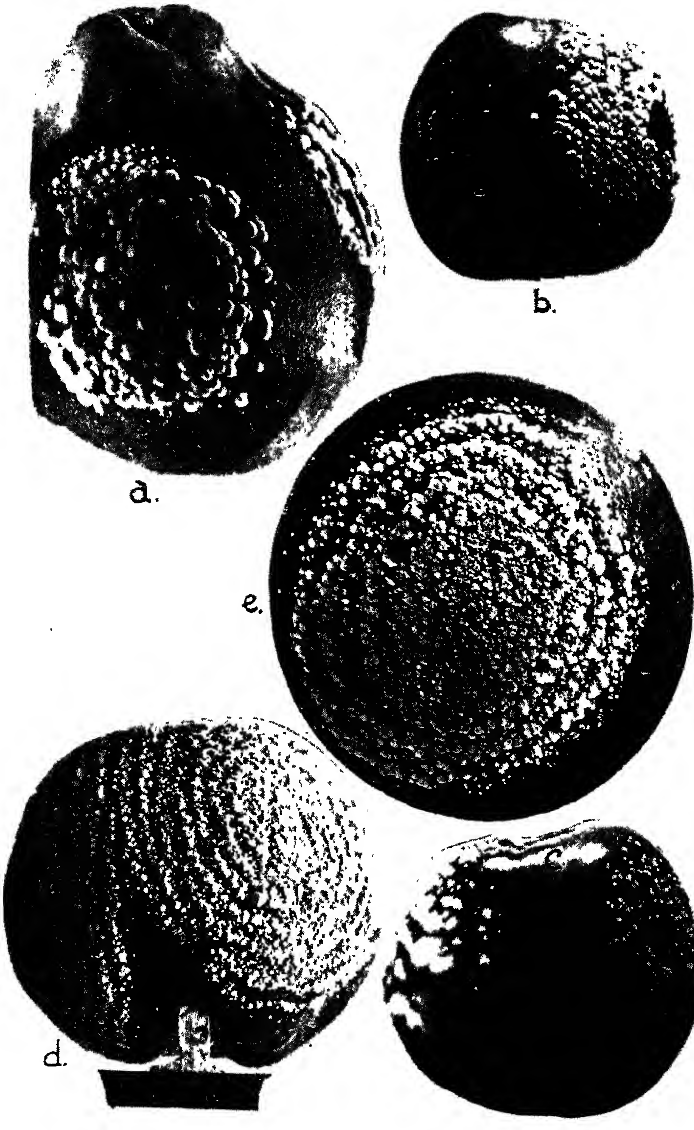
The facts presented by him are entirely in agreement with the published descriptions of the Monilia stage of *S. fructicola*, and with its appearance in Australia, with the possible exception that he does not mention that the conidial tufts assume a fawn tint on maturity. Climatic conditions may prevent this in New Zealand.

In January, 1928, the author received from Dr. Cunningham cultures labelled "Brown Rot, Apricots, Wellington." The macroscopic appearance of this fungus, when grown on Potato Dextrose Agar slopes and plates, is certainly that of *S. fructicola* and not that of *S. cinerea*.

Conidia from the New Zealand fungus have been germinated under identical conditions with those of *S. fructicola* obtained from American and Australian sources and with those of *S. cinerea*. The New Zealand fungus is inseparable from *S. fructicola* by this means, but very distinct from *S. cinerea*.

Cultures and mummified fruits have also recently been received from Dr. K. N. Curtis. The cultures thus obtained made available five "strains"* of the New Zealand Brown Rot organism. These have been grown side by side with the local "strain" of *Sclerotinia*, with Ezekiel's six

* Throughout this paper the word "strain" is used in the same sense as that defined by Wormald (52)—i.e., a pure line, which may or may not be identical with others.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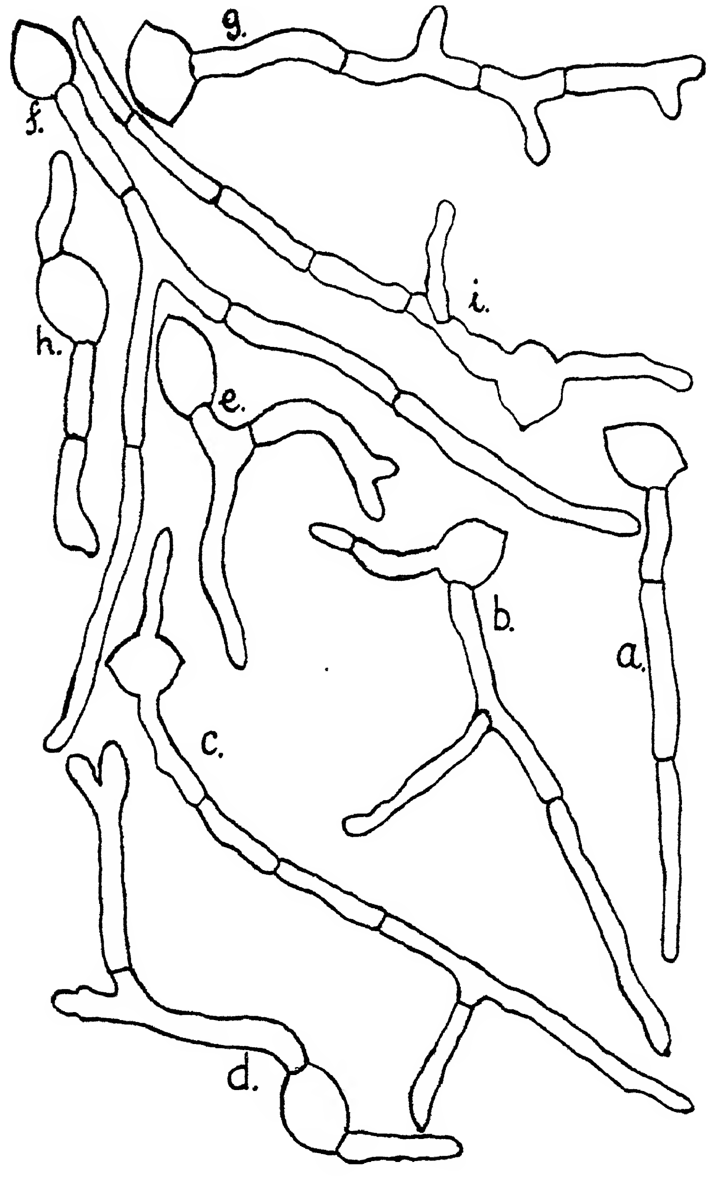
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biologic forms of *S. fructicola* and with *S. cinerea* from England.

The observations made, as well as the facts presented above, support the contention of Dr. Wormald that the fungus commonly responsible for Brown Rot in New Zealand is identical with that occurring in America and in Australia, and therefore should be called *Sclerotinia fructicola* (Wint.) Rehm.

Acknowledgments.

The author is indebted to all those from whom cultures, specimens, information or assistance were received, and to the Faculty of Agriculture, University of Sydney, in whose laboratories the work was prosecuted in 1921, 1922, and early 1923.

Finally, it is a special privilege gratefully to acknowledge the inspiration, assistance and kindly criticism so generously given at all times by Mr. W. L. Waterhouse, Faculty of Agriculture, University of Sydney.

SUMMARY.

1. Brown Rot of deciduous fruits was introduced to Australia in the nineties of last century. It was first recognised in 1896 by McAlpine, in Victoria. Its subsequent history is traced.

2. The disease is at present well established in most of the temperate fruit-growing regions of the south-eastern fringe of Australia. It is not known in South Australia or in Western Australia.

3. The host range in Australia is given—the organism causes fruit-rotting, twig-blighting, blossom-blighting, and cankering of stone fruits particularly.

4. The history of the nomenclature of the organisms responsible for Brown Rot of fruits in other parts of the world and in Australia is traced.

5. A series of comparative experiments was conducted. Standard cultures of *S. cinerea*, *M. fructigena*, and *S. fructicola* were compared with the Australian Brown Rot fungus. Full details are published.

6. Apothecia are recorded from apple, apricot, peach, and plum during the years 1922, 1923, and 1924. Complete taxonomic details are presented.

7. The conclusion is reached that the organism responsible for Brown Rot in Australia is *S. fructicola* (Wint.) Rehm.

8. The production of apothecia of *S. fructicola* from apple is discussed.

9. The organism responsible for Brown Rot in New Zealand is also considered to be *S. fructicola*.

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EXPLANATION OF PLATES.

Plate V.

a. A peach mummy bearing exceptionally large apothecia. The seed within the sclerotium has germinated. The scale is in millimetres. Collected at Beecroft, Sept., 1922.

b. Typical apothecia from a plum mummy. Note the curved stipes, due to the apothecia coming from beneath the mummy, which was partly submerged by soil. Collected at Beecroft, September, 1922.

c. A very large apothecium from a plum mummy. The scale is in millimetres. Collected at Beecroft, Sept., 1922.

d. A group of apothecia from a plum mummy. These apothecia were collected when in the stipe stage and their development studied. Collected at Beecroft, Sept., 1922.

e. Apothecia on an apple mummy. The crateriform apothecium opposite the arrow on the left is that of *S. fructicola* and the smaller flattened ones on the right are those of *S. aestivalis*. Collected at the University, Sept., 1922.

f. An apothecium, *in situ*, arising from a submerged plum mummy. The cup always opens just above ground level. Photographed at Beecroft, September, 1922.

g & h. Apothecia from plum mummies which were derived from newly-formed fruits. Collected at Beecroft, September, 1922.

Photographs by Mr. W. L. Waterhouse or by Faculty of Agriculture, Sydney University.

Plate VI.

a. A group of apothecia, *in situ*, attached to a partly exposed plum mummy. The weed is *Hypochaeris radicata* L. Photographed at Beecroft, September, 1922.

b. Small apothecia arising from a submerged sclerotium. Photographed, *in situ*, at Beecroft, 1922. The coin (½d.) has a diameter of 25 mm.

c. A cluster of Japanese plums infected by Brown Rot while still less than half grown. The small pinhead-like tufts are typical of *S. fructicola* in Australia. Collected at Pennant Hills, January, 1922.

d. A plum tree typical of those in the neglected orchard where the apothecia were abundant in Sept., 1923. The tree was in flower at the time when the apothecia were collected.

Photographs a, b and d by Mr. W. L. Waterhouse.

Photograph c by Faculty of Agriculture.

Plate VII.

a. Typical asci from an apothecia of *S. fructicola* from plum mummy. Collected at Beecroft, Sept., 1922.

b. Paraphyses.

c. Ascospores.

d. Germinating ascospores—in distilled water for various periods.

e. Ascospores germinating within the ascus. This phenomenon was abundant in material kept under moist conditions.

f. A gelatinous sheath surrounds the germ tubes.

All the above were drawn, at magnification of approximately 900, with aid of camera lucida.

Plate VIII.

a. *Monilia fructigena* of England on quince 8 days after inoculation. Photographed 29/5/'22.

b. A Trivett Seedling apple showing *Monilia fructigena* on the right and the Australian Brown Rot organism (*S. fructicola*) on the left.

c. A Trivett Seedling apple with *Monilia fructigena* on the left and the Australian organism (*S. fructicola*) on the right. Note the large white fluffy masses of hyphae which precede conidial production in *Monilia fructigena* and the entire absence of surface mycelium in *S. fructicola*.

d. Typical fructifications of *S. fructicola*, in Australia, on quince, 11 days after inoculation.

e. The fructifications of *S. fructicola* at close range on the same quince as in d, taken 8 days after inoculation.

Photographs taken by Faculty of Agriculture.

Plate IX.

Germinating conidia of *S. fructicola*, drawn with the aid of "camera lucida"; in hanging drop of potato decoction for 24 hours at temperature which varied from 15-10°C.

a. From culture No. 200, obtained from single ascospore of an apple apothecium, Sept., 1922. Length of germ tube approx. 140 μ $\times$ 490.

b. From culture No. 8 from New Zealand. The length of germ tube is 200 μ and from the conidium to the branch is approx. 50 μ. × 350.

c. From culture No. 200. Note the double germination and the branching of the germ tube at 230 μ from the conidium. × 300.

d. From culture of *S. fructicola* received from Ezekiel under name *S. americana* form I. (S22). Note the double germination and the branching at approx. 50 μ. × 500.

e. As d, with dichotomous branching at a distance of approx. 15 μ from the conidium. × 500.

f. As b. Dichotomous branching has taken place at 65 μ. × 350.

g. As d. Note the development of several branches, the nearest of which is approx. 70 μ from the conidium. × approx. 600.

h. As d. Showing double germination of conidium.

i. As b. Showing double germination and branching. The longest germ tube is approx. 240 μ long and the branch is being sent out at approx. 35 μ from conidium. × approx. 400.

ACACIA SEEDLINGS PART XIII.

By R. H. CAMBAGE, C.B.E., F.L.S.

(With Plates X. to XIII.)

(Read before the Royal Society of New South Wales, Aug. 1st, 1928.)

SYNOPSIS.

VITALITY OF SEEDS IN SEA-WATER.

DESCRIPTION OF SEEDLINGS.

Vitality of Seeds in Sea-Water.

In Part VI of this series* it was mentioned that four pods of *Acacia Farnesiana*, containing seeds, had floated in sea-water for ten to twelve weeks before sinking. At the end of seven and a half years these seeds were examined, when more than half were found to be decaying. From among those which looked to be well preserved, one was placed in boiling water and planted, after which it readily germinated.

Recently a seed of *A. melanoxylon*, collected at Jenolan Caves, and left in sea-water for ten years, germinated after having been placed in boiling water and planted.

In 1856, Charles Darwin tested many seeds of various genera, but not including *Acacia*, in sea-water, but the best result he obtained on that occasion was in the case of *Apium graveolens* (Umbelliferae), six seeds of which germinated after having been immersed for 137 days.†

James Salter records the germination of many seeds of various genera taken from the mud of the Thames in 1843,

*This Journ. 1920, 54, 146.

†Journ. of the Proc. Linn. Soc. London, 1857, I, 130. See also "Observations of a Naturalist in the Pacific between 1896 and 1899" by H. B. Guppy. Plant-Dispersal, 1906, 2, 22.

but although some of these seeds were probably lying in the mud under the salt water for some considerable periods, there is no certainty as to the length of time they were immersed.‡ The genera referred to were *Centaurer, Epilobium* and *Lysimachia,* and it is stated that no plants of these species were growing previously within from two to ten miles of the spot where the mud was spread.

Description of Seedlings.

CALAMIFORMES—(Uninerves).

ACACIA ERICIFOLIA Benth. Seeds from Wongan Hills, Western Australia (W. M. Carne). (Plate X, Numbers 1 to 3.)

Seeds dark brown to black, oblong to obovate, 2 to 2.5 mm. long, about 1 mm. broad, 1 mm. thick.

Hypocotyl terete, brownish-red to reddish-brown, 1.3 to 2 cm. long, about 0.6 mm. thick at base, 0.5 mm. at apex.

Cotyledons sessile, oblong, apex rounded, 3 mm. long, about 1.5 mm. broad, upperside green, underside pale green to brownish-green, sometimes with raised line along centre.

Stem terete, greenish-brown, pilose. First internode 0.5 mm.; second and third 0.5 to 1 mm.; fourth to sixth 1 to 3 mm.; seventh to tenth 2 to 5 mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 4 mm., glabrous; leaflets two pairs, obovate, 2.5 to 3 mm. long, 1 to 2 mm. broad, upperside green, underside pale green; rachis 1.5 to 2 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 4 to 9 mm., glabrous, with terminal seta; leaflets two pairs, obovate, 1.5 to 3 mm. long, 1 to 1.5 mm. broad, upperside green, underside paler; rachis about 2 mm., with terminal seta.

‡"On the Vitality of Seeds after prolonged Submersion in the Sea," by James Salter, M.D., F.L.S. Journ. of the Proc. Linn. Soc., 1857, I, 140.

Nos. 3 to 5. Abruptly bipinnate, petiole 7 mm. to 1.3 cm., sometimes slightly flattened in the case of No. 5, glabrous: leaflets two to three pairs, oblong-acuminate to obovate; rachis 4 to 5 mm.; stipules acuminate, 1 mm.

Nos. 6 and 7. These may be phyllodes, or abruptly bipinnate, petiole up to 1.1 cm. long, up to 1.5 mm. broad, glabrous; leaflets two to three pairs; rachis 3 to 5 mm.

Nos. 8 to 15. Usually thick phyllodes, cuneate, obtuse or very shortly acuminate, tapering from near the apex to the base, the midrib sometimes showing slightly under pocket lens, 1 to 2 cm. long, up to 5 mm. broad near apex. The terminals of later phyllodes are more tapering.

In this Journal (1926, 60, 85), reference is made to the nocturnal movement of seedling leaves of this species. species.

UNINERVES—(Racemosae).

ACACIA CAESIELLA Maiden and Blakely.* Seeds from Burrinjuck (E. C. Andrews and J. W. Campbell). (Plate X, Numbers 4 to 6.)

Seeds black, oblong-oval to obovate, about 4.5 mm. long, 2 to 3 mm. broad, about 1.5 mm. thick.

Hypocotyl red, constricted above soil, expanding into flange at root, 2 to 3 cm. long, 2 to 2.6 mm. thick at base, 0.7 to 1 mm. at apex.

Cotyledons sessile, auricled, oblong, about 5 to 6 mm. long, 2.5 to 3 mm. broad, upperside at first red, becoming green, underside red, becoming revolute in one day and later cylindrical.

Stem terete, reddish-brown, hirsute to hoary, silky towards the summit. First internode 0.5 mm.; second to fifth 0.5 to 0.8 mm.; sixth to tenth 0.8 to 1.5 mm.

*This Journ., 1926, 60, 180.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 6 mm., glabrous; leaflets three to four pairs, oblong-acuminate, the apical pair often obovate, 5 to 6 mm. long, 1.5 to 2 mm. broad, upperside reddish-green, underside red; rachis 6 to 8 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 8 mm. to 1.1 cm., pilose, with terminal seta; leaflets three to five pairs, oblong-acuminate, 3 to 6 mm. long, 1 to 3 mm. broad; rachis 7 mm. to 1 cm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 9 mm. to 1.7 cm., pilose; leaflets three to eight pairs; rachis 7 mm. to 2.1 cm.

Nos. 5 to 7. Abruptly bipinnate, petiole 1.5 to 2.5 cm., No. 7 being sometimes 2 mm. broad, hirsute; leaflets six to eleven pairs; rachis 1.5 to 2.5 cm.

Nos. 8 to 10. These may be phyllodes, or abruptly bipinnate, petiole 1.7 to 2.1 cm. long, 1 to 2 mm. broad, with a strong nerve just below the centre of the lamina, hirsute; leaflets eight to ten pairs, often mucronate; rachis 1.2 to 1.8 cm.

Nos. 11 to 20. Lanceolate, slightly falcate phyllodes, 1.5 to 2.7 cm. long, 4 to 5 mm. broad, the midrib prominent on both sides, with a small gland towards the base on the upper margin, minutely hoary.

PLURINERVES—(Microneurae).

ACACIA HOMALOPHYLLA A. Cunn. "Yarran". Seeds from Gunnedah (J. H. Maiden). (Plate X, Numbers 7 to 9.)

Seeds dark brown, oblong-oval to almost orbicular, 3 to 5 mm. long, 2.5 to 3 mm. broad, 1 to 1.5 mm. thick.

Hypocotyl terete, green to reddish, 1.5 to 2 cm. long, 1.5 mm. thick at base, 0.8 to 1 mm. at apex.

Cotyledons sessile, auricled, oblong-oval, 6 to 7 mm. long, 4 to 5 mm. broad, upperside green, underside pale green, becoming slightly revolute, and doubling downwards beyond the middle.

Stem terete, greenish-brown, pilose. First internode 0.5 mm.; second 0.5 to 1 mm.; third 1 to 2 mm.; fourth 3 mm. to 1 cm.; fifth to seventh 5 mm. to 1.4 cm.; eighth to tenth 8 mm. to 2 cm.

Leaves—No. 1. Abruptly pinnate, in one case an opposite pair appeared, petiole 3 to 4 mm., glabrous; leaflets three to four pairs, rarely one, oblong-acuminate, the apical pair sometimes obovate, 4 to 7 mm. long, about 2 mm. broad, upperside green, underside pale green; rachis 3 to 9 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 7 mm. to 1.1 cm., green, glabrous, with terminal seta; leaflets two to four pairs, oblong-acuminate, the apical pair sometimes obovate, 3 to 5 mm. long, 1 to 2 mm. broad, upperside green; rachis 4 to 7 mm., glabrous, with terminal seta.

Nos. 3 to 5. Abruptly bipinnate, petiole 8 mm. to 3.5 cm., faintly pilose; leaflets three to six pairs; rachis 6 mm. to 1.6 cm.

Nos. 6 to 9. Abruptly bipinnate, petiole 1.2 to 6.6 cm. long, 1 to 5 mm. broad, usually with a very definite midrib and several much finer parallel veins, faintly pilose; leaflets three to six pairs, rarely seven; rachis 6 mm. to 1.5 cm.

Nos. 10 to 17. These may be phyllodes, or abruptly bipinnate, petiole 1.7 to 6.5 cm. long, 3 to 7 mm. broad, with a definite midrib and a vein on each side of it less prominent but more definite than the numerous other parallel veins, faintly pilose or hoary; leaflets four to six pairs; rachis 6 mm. to 1.8 cm.

Nos. 18 to 25. Lanceolate-falcate or linear-lanceolate, very brittle phyllodes, from about 4 to 7 cm. long, obtuse and often with a fine point, venation similar to Nos. 10 to 17.

PLURINERVES—(Nervosae).

ACACIA HARPOPHYLLA F. v. M. "Brigalow." Seeds from Eidsvold, Queensland (Dr. T. L. Bancroft). (Plate XI, Numbers 1 to 3.)

Seeds grey, irregularly oblong to oblong-oval, with raised lines or corrugations on both sides, 1 to 1.5 cm. long, 4 to 6 mm. broad, 1.5 to 2 mm. thick.

These seeds, with their irregular, often shrivelled-looking shape and fairly soft testa, differ from all other Australian *Acacia* seeds so far seen.

Hypocotyl terete, red above soil, 3 to 5 cm. long, about 2 mm. thick at base, 1 to 1.5 mm. at apex.

Cotyledons sessile, deeply auricled, oblong-ovate, about 1.6 cm. long, 7 mm. broad, upperside green, underside yellowish-green to pale green.

Stem terete, greyish-green, glabrous to minutely hoary. First internode 0.5 mm.; second 1 mm.; third 2 to 4 mm.; fourth to eighth 5 mm. to 1.5 cm.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair, petiole 4 to 6 mm., glabrous; leaflets four to six pairs, oblong-acuminate, 4 mm. to 1 cm. long, 1 to 3 mm. broad, upperside green, underside paler; rachis 1 to 1.7 cm. with terminal seta.

No. 2. Linear-lanceolate phyllode, 3 to 7 cm. long, 2 to 5 mm. broad, with a fairly definite central nerve, and many finer parallel ones.

Nos. 3 to 8. Linear-lanceolate falcate phyllodes, sparsely covered with a fine tomentum seen under a pocket lens, but

not so dense as on later phyllodes, 4 to 12 cm. long, 4 mm. to 1.2 cm. broad, with numerous fine longitudinal veins, and one or two more prominent than the rest showing in Nos. 3 to 5.

PLURINERVES—(Nervosae).

ACACIA CONFUSA Merrill.* The species is a native of Formosa. Seeds from Hongkong Botanic Gardens (Cultivated, H. Green). (Plate XI, Numbers 4 to 6.)

Seeds brown, oval to oblong-oval, areola distinct, 5 to 6 mm. long, 3.5 to 4 mm. broad, about 1.5 mm. thick.

Hypocotyl brownish-green, spreading into flange at root, 2 to 3 cm. long, about 2 mm. thick at base, 1 mm. at apex.

Cotyledons sessile, auricled, oblong-oval to almost oval, about 7 mm. long, 4 to 5 mm. broad, upperside green, underside pale green.

Stem terete, greenish-brown, glabrous. First internode 0.5 to 1 mm.; second 1 to 3 mm.; third and fourth 3 mm. to 1 cm.; fifth and sixth 6 mm. to 1.5 cm.

Leaves—No. 1. Abruptly pinnate, in a few cases forming an opposite pair, petiole 4 to 7 mm., brownish-green, glabrous; leaflets one to two pairs, oblong-acuminate, 6 mm. to 1.3 cm. long, 3.5 to 5 mm. broad, upperside green, underside paler, venation distinct on underside.

No. 2. Obovate-lanceolate phyllode, obtuse, often mucronate, 1.5 to 3 cm. long, 3.5 to 9 mm. broad, with a central nerve, and usually a finer one on each side of it not confluent at the apex.

Nos. 3 to 10. Oval-lanceolate to lanceolate phyllodes, obtuse, often mucronate, 2.5 to 7 cm. long, 8 mm. to 1.5 cm. broad, with about five distinct nerves mostly confluent at the apex and with sometimes one or two finer veins not

*Philipp. Journ. Sci., 1910, 5, 27.

reaching the apex. Later phyllodes are lanceolate-falcate and longer.

This is the fourth seedling described in this series where the No. 2 leaf is usually reduced to a phyllode, the previous cases being *A. alata, A. Cambagei** and *A. harpophylla* (*supra*).

JULIFLORAE—(Stenophyllae).

ACACIA MERINTHOPHORA Pritzel.† Seeds from Wongan Hills, Western Australia (W. M. Carne). (Plate XI, Numbers 7 to 9.)

Seeds light brown, oblong-obovate, 2.5 to 3.5 mm. long, 1.5 to 2 mm. broad, 1 mm. thick.

Hypocotyl terete, brownish-red above soil, 1.5 to 2 cm. long, 1 mm. thick at base, about 0.5 mm. at apex.

Cotyledons sessile, auricled, oblong, about 4 mm. long, 2 mm. broad, upperside green, underside brownish-red to greenish-brown.

Stem terete, greyish-green, glabrous. First internode 0.5 mm.; second and third 1 to 2 mm.; fourth to eighth 2 mm. to 1 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 4 mm.; leaflets two pairs, 2 to 4 mm. long, 1 to 2 mm. broad, oblong to obovate, upperside green, underside brownish-green; rachis 1.5 to 2 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 2 to 5 mm., glabrous, with terminal seta; leaflets two to three pairs, oblong to obovate, 2 to 4 mm. long, 1 to 2 mm. broad, rachis 2 to 3 mm., with terminal seta.

No. 3. This may be a phyllode, or abruptly bipinnate, petiole 1 to 1.3 cm. long, up to 1 mm. broad; leaflets two to three pairs, rachis 1 to 4 mm.

*This Journ., 1926, 60, 96.
†Engler's Bot. Jahrb., 1905, 35, 307.

Nos. 4 to 6. Linear phyllodes 2 to 7 cm. long, up to 2.5 mm. broad, with central nerve.

Nos. 7 to 9. Linear phyllodes, 5 to 11 cm. long, up to 1.5 mm. broad, with definite central nerve, and one or two finer ones on each side, often with hooked points.

JULIFLORAE—(Stenophyllae).

ACACIA LINOPHYLLA W. V. Fitzgerald.* Seeds from Gascoyne River, Canarvon, Western Australia (E. C. Andrews). (Plate XII, Numbers 1 to 3.)

Seeds brown, irregularly oval to almost quadrangular, areola depressed, 5 to 7 mm. long, 5 to 6 mm. broad, about 3 mm. thick.

Hypocotyl green to brownish-green, 1.5 to 3 cm. long, 3 mm. thick at base, 1.5 to 2 mm. at apex.

Cotyledons oblong to oblong-oval, auricled, about 1 to 1.2 cm. long, 6 to 6.5 mm. broad, upperside green, underside pale green.

Stem terete, brownish-grey, glabrous. First internode 0.5 mm.; second 1 mm.; third to sixth 2 to 5 mm.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair, petiole 4 to 8 mm., green, glabrous; leaflets three pairs, oblong-acuminate to obliquely-ovate, 4 to 6 mm. long, 1.5 to 3 mm. broad, upperside green, underside pale to yellowish-green; rachis 7 to 9 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 1.5 to 2.2 cm., with terminal seta; leaflets three pairs, oblong-acuminate, 2 to 4 mm. long, 1 to 2 mm. broad; rachis 4 to 8 mm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, or No. 4 may be a phyllode, sometimes with two pairs of pinnae, petiole 2 to

*Journ. W.A. Nat. Hist. Soc., 1904, 16.

3 cm., sometimes up to 1 mm. broad; leaflets two to three pairs; rachis 1 to 2 mm.

Nos. 5 to 15. Linear phyllodes, about 3 to 13 cm. long, flattened, sometimes up to 1.5 mm. broad in the case of Nos. 5 to 8, Nos. 9 to 15 narrower, with a few closely-packed veins seen under pocket lens, stipules up to about 2 mm.

Phyllodes on mature trees are terete.

JULIFLORAE—(Falcatae).

ACACIA ARGENTEA Maiden.* Seeds from Eidsvold, Queensland (Dr. T. L. Bancroft). (Plate XII, Numbers 4 to 6.)

Seeds brown, oblong, 3 to 4 mm. long, 1.5 mm. broad, 1 mm. thick.

Hypocotyl terete, pink to reddish, spreading into flange at root, 2 to 2.5 cm. long, about 1.5 mm. thick at base, 0.5 to 0.7 mm. at apex.

Cotyledons sessile, sagittate, oblong, 5 mm. long, 1.5 to 2 mm. broad, upperside green, underside red.

Stem at first angular, becoming terete, greenish-red, hirsute to pubescent. First internode 0.5 mm.; second and third 1 to 2 mm.; fourth to sixth 2 to 5 mm.; seventh to tenth 4 to 7 mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3 mm.; leaflets two pairs, oblong-acuminate, 4 to 6 mm. long, 1.5 to 2 mm. broad, upperside green, underside pale green; rachis 2 to 3 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 3 to 4 mm., glabrous, with terminal seta; leaflets two to three pairs, oblong-obovate to obliquely obovate, 3 to 4 mm. long, 1 to 2 mm. broad, upperside green; rachis 3 to 5 mm., with terminal seta.

*Proc. Roy. Soc. Queensland, 1918, 30, 41.

Nos. 3 and 4. Abruptly bipinnate, petiole 5 mm. to 1.2 cm., hirsute; leaflets three to six pairs; rachis 4 mm. to 1.2 cm.

Nos. 5 to 7. Abruptly bipinnate, sometimes with two pairs of pinnae in the case of No. 7, petiole hirsute, 8 mm. to 4.8 cm. long, up to 2 mm., 4 mm., and 7 mm. broad in the cases of Nos. 5, 6 and 7 respectively, usually with a strong nerve along or near the lower margin and several very fine veins above in the cases of Nos. 6 and 7; leaflets five to nine pairs, margins ciliate; rachis 7 mm. to 1.7 cm.

Nos. 8 and 9. These may be phyllodes or abruptly bipinnate, petiole hirsute, 5 to 6 cm. long, 7 to 8 mm. broad, with two fairly distinct nerves, the main one below the centre of the lamina, the other, and sometimes a fainter one from the base to the middle, above, and numerous very fine parallel veins; leaflets seven to eight pairs; rachis about 1 cm.

Nos. 10 to 14. Lanceolate-falcate phyllodes, venation much as described in the cases of the petioles of Nos. 6 and 7, 5 to 7 cm. long, and up to 1 cm. broad, minutely hoary, with a somewhat silvery sheen.

BIPINNATAE—(Botryocephalae).

ACACIA MOLLISSIMA Willd.* Sydney Black Wattle. Seeds from Milton, New South Wales. (Plate XIII, Numbers 1 to 3.)

Seeds dull black, oval to oblong-oval, 4 to 5 mm. long, 2 to 3 mm. broad, 1.5 to 2 mm. thick.

Hypocotyl terete, reddish to red, 1.5 to 5 cm. long, about 1 mm. thick at base, 0.7 mm. at apex.

Cotyledons sessile, auricled, oblong, soon becoming revolute and cylindrical, about 5 mm. long, 2 to 3 mm. broad, upperside green to reddish-green, underside pale green to reddish.

*Enum. Hort. Berol. 1053.

Stem terete, reddish-green, pilose to tomentose. First internode 0.5 mm.; second 0.5 to 1 mm.; third 1 to 5 mm.; fourth and fifth 3 to 9 mm.; sixth and seventh 5 mm. to 3.5 cm.; eighth and ninth 1 to 4.5 cm. The longest internodes were found on natural seedlings.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 5 mm., reddish-brown, glabrous; leaflets three to five pairs, oblong-acuminate, 4 to 7 mm. long, 1 to 2 mm. broad, upperside green, underside reddish-brown, margins reddish; rachis 3 to 9 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 3 to 8 mm., with small gland, reddish-brown, glabrous to pilose, with terminal seta; leaflets five to six pairs, oblong-acuminate, the apical pair often obovate, 4 to 5 mm. long, 1 to 2 mm. broad, upperside green, underside reddish-green; rachis 6 mm. to 1 cm., with terminal seta.

Nos. 3 to 5. Abruptly bipinnate, sometimes with two pairs of pinnae, petiole 5 mm. to 2.3 cm., with gland on upper margin, pilose; leaflets seven to ten pairs, similar to those of No. 2; rachis 1 to 3 cm.

Nos. 6 and 7. Abruptly bipinnate, usually with two or three pairs of pinnae, petiole 1.5 to 2.8 cm., with one or sometimes two glands on upper margin, pilose; leaflets about twelve to twenty-two pairs, up to 6 mm. long, about 1 mm. broad; rachis 1.5 to 3.3 cm.

Nos. 8 to 10. Abruptly bipinnate, with from three to six pairs of pinnae, petiole 3.4 to 4.5 cm.; leaflets up to twenty-four pairs, flat, oblong-acuminate, apical pair obovate, margins ciliate, 7 to 8 mm. long in central portion of pinna, about 1.5 mm. broad; rachis 2.7 to 3.5 cm.

This species flowers in about November, and takes twelve months to ripen its pods, whereas *A. decurrens*, of

which *A. mollissima* has been regarded as a variety, flowers in August, and ripens its pods by the end of the following December.

GUMMIFERAE.

ACACIA HORRIDA Willd.* Extratropical South Africa. Seeds from the University Grounds, near Melba Hall, Melbourne. (Cultivated.) (Plate XIII, Numbers 4 to 6.)

Seeds brown, oblong-oval, areola distinct, 5 to 6 mm. long, 3.5 to 5 mm. broad, 1.5 to 2 mm. thick.

Hypocotyl terete, pale green, 1.5 to 3 cm. long, about 1.7 mm. thick at base, 1.5 mm. at apex.

Cotyledons fleshy, deeply auricled, petiolule 2 to 3 mm. long, oblong to ovate-oblong and oblong-oval, 8 mm. to 1 cm. long, 5 to 7 mm. broad, upperside at first yellowish-green, becoming green, underside pale green.

Stem terete, greyish-brown, glabrous. First internode 0.5 mm.; second 2 to 4 mm.; third to sixth 2 to 6 mm.; seventh to tenth 4 to 7 mm.

Leaves—No. 1. Abruptly pinnate, petiole 4 to 6 mm.; glabrous; leaflets four to five pairs, oblong-acuminate, 4 to 8 mm. long, 2 to 3.5 mm. broad, upperside green, underside pale green; rachis about 1 cm., with terminal seta.

No. 2. Abruptly bipinnate, in one case an abnormal leaf was simply pinnate, petiole 4 to 6 mm., with terminal seta; leaflets two to five pairs, oblong-acuminate, 3 to 5 mm. long, 1 to 2 mm. broad; rachis 5 mm. to 1 cm., with terminal seta.

Nos. 3 to 6. Abruptly bipinnate, petiole 5 to 7 mm., glabrous; leaflets five to nine pairs; rachis 1 to 2 cm.; stipules linear, up to 4 mm.

*See "Revision of the Suborder Mimoseae." By George Bentham, F.R.S., Trans. Linn. Soc. London, 1875, 30, Part III, 507.

Nos. 7 to 10. Abruptly bipinnate, petiole 6 to 9 mm.; leaflets six to nine pairs; rachis 1.4 to 2 cm.

Nos. 11 to 16. Abruptly bipinnate, sometimes twice pinnate in the case of No. 13 and upwards, petiole 6 mm. to 1 cm., often with a gland at the base of each pair of pinnae; leaflets eight to ten pairs; rachis 1.3 to 2.1 cm.; stipules spinose, up to 8 mm.

A pot plant about 4 feet high produced leaves with from one to four pairs of pinnae, and from eight to fourteen pairs of leaflets, with usually a gland or nectary at the base of each pair of pinnae, and sometimes with a pair of glands (laterally) at the bases of the second and third pairs of pinnae but not of the basal or apical pairs; the common petiole being up to 4 cm. long and almost square in cross section; spines up to 2.5 cm. A spine on the parent tree measured 6.3 cm. long.

So far I have not seen glands or nectaries occurring in pairs on a phyllodineous *Acacia*, but A. D. Hardy records its occurrence on *A. decurrens* of the Bipinnatae section.*

During the winter months the leaflets of *A. horrida* remain partly closed up even during a sunny day, and show much more evidence of leaf sleep than do those of most species of the Australian subgenus Botryocephalae.

Explanation of Plates.

Plate X.

Acacia ericifolia Benth.

1. Cotyledons, Wongan Hills, Western Australia (W. M. Carne).
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds.

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*See "The distribution of leaf glands in some Victorian Acacias," by A. D. Hardy, F.L.S., Vict. Nat., 1912, 29, 26.

Also "Observation on the function of Acacia leaf glands," by Reginald Kelly, *Ib.*, 1913, 30, 121.

Acacia caesiella Maiden and Blakely.

4. Cotyledons, Burrinjuck (E. C. Andrews).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Pod and seeds.

Acacia homalophylla A. Cunn.

7. Cotyledons and pinnate leaf, Gunnedah (J. H. Maiden).
8. Pinnate leaf, bipinnate leaves and phyllodes.
9. Pod and seeds.

Plate XI.

Acacia harpophylla F. v. M.

1. Cotyledons, Eidsvold, Queensland (Dr. T. L. Bancroft).
2. Opposite pair of pinnate leaves and phyllodes.
3. Pod and seeds.

Acacia confusa Merrill.

4. Cotyledons and pinnate leaf, Botanic Gardens, Hongkong (H. Green).
5. Pinnate leaf and phyllodes.
6. Pod and seeds.

Acacia merinthophora Pritzel.

7. Cotyledons, Wongan Hills, Western Australia (W. M. Carne).
8. Pinnate leaf, bipinnate leaves and phyllodes.
9. Portion of pod and seeds.

Plate XII.

Acacia linophylla W. V. Fitzgerald.

1. Cotyledons and pair of pinnate leaves, Gascoyne River, Western Australia (E. C. Andrews).
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds.

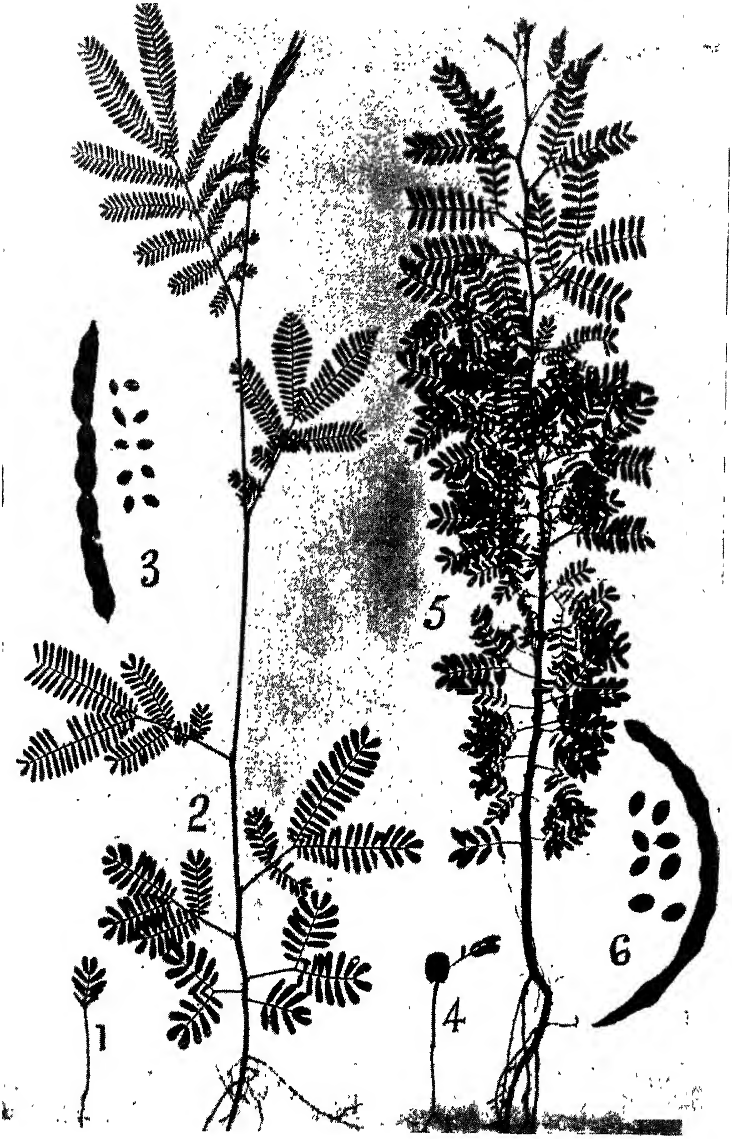
Acacia argentea Maiden.

4. Cotyledons, Eidsvold, Queensland (Dr. T. L. Bancroft).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Pod and seeds.

Acacia ericiafolia (1 - 3); *Acacia caesiella* (4 - 6); *Acacia homalophylla* (7 - 9).
Three-fifths Natural Size.

Acacia harpophylla (1 - 3) ; *Acacia confusa* (4 - 6) ; *Acacia merinthophora* (7 - 9).
Nearly Three-fourths Natural Size.

Acacia linophylla (1 - 3) ; *Acacia argentea* (4 - 6).
Three-fifths Natural Size.



Acacia mollissima (1-3); *Acacia horrida* (4-6).
About Half Natural Size.

Plate XIII.

Acacia mollissima Willd.

1. Cylindrical cotyledons and pinnate leaf, Milton, New South Wales.
2. Pinnate leaf and bipinnate leaves.
3. Pod and seeds.

Acacia horrida Willd.

4. Cotyledons and pinnate leaf, The University Grounds, near Melba Hall, Melbourne (Cultivated).
5. Pinnate leaf and bipinnate leaves.
6. Pod and seeds.

THE GEOLOGY OF PORT STEPHENS.

Part I.—Physiography and General Geology.

By C. A. Sussmilch and Wm. Clark.

Part II.—Petrography.

By C. A. Sussmilch, with Analyses by W. A. Greig.

(With Plates XIV-XVI and two Text-figures.)

(Read before the Royal Society of New South Wales, Sept. 5, 1928.)

The area described in this paper comprises the whole of the parish of Tomaree (County of Gloucester), together with part of the adjoining parish of Sutton. The north head of Port Stephens, which is part of the parish of Fens, is also included. Brief reference to some of the geological features of this area is made by Sir T. W. E. David in his memoir on the Hunter River coalfield,[1] and part of the area is shown in his geological map.

Part I.—Physiography and General Geology.

A. Physiography.

This region consists of a prominent group of isolated hills on the southern side of Port Stephens, rising above a swampy sand flat, the latter being elevated but little above sea level excepting where it is covered in part by low sand dunes. The hills are the summits of partly-buried ridges, consisting of lava flows of Carboniferous age.

When the submergence took place in late Pleistocene times which drowned the shore line and produced the inlet of Port Stephens, these ridges were partly submerged, only

the higher points remaining as islands; silting followed the subsidence, and the thickness of the silts, as shown by the bores put down near Anna Bay, is not less than 190 feet, thus indicating a subsidence of at least that amount. A more recent elevation of from 15 to 20 feet has lifted the area above sea level and produced the swampy plain, above which the one-time islands now rise as hills. Two of these hills, viz., Yacaaba (north head) and Point Stephens, are joined to the mainland by narrow sand spits which are sometimes awash at high tide. The islands which adjoin the entrance to Port Stephens, namely, Cabbage Tree Island and Boondalbah Island, are similar peaks which have not been rejoined to the mainland.

The majority of the hills above referred to rise to a general elevation of about 400 feet above sea level, and this level would appear to be an erosion level, corresponding in altitude to one which occurs in the Hunter River Valley, and which one of us (C.A.S.) has referred to elsewhere as the Charleston level.[2] Three of the hills, however, rise above this level, namely:

Yacaaba (North Head), altitude 717 ft.
Tomaree (South Head), altitude 540 ft.
Ghan Ghan (Trig. Station), altitude 527 ft.

Similar isolated hills occur to the north and west of Port Stephens, such as Mt. Karuah (807 ft.), Mt. Gundain (833 ft.), Mt. Carrington (875 ft.), and Mt. Nerong (1,000 ft.). The whole region, therefore, appears to have been a Tertiary peneplain which was uplifted to form a tableland about 1,000 feet in altitude at the close of the Tertiary period, the various hills of to-day being residuals of this tableland.

Port Stephens is a typical drowned valley with its long axis (13 miles) in an east and west direction. It is divided into two unequal parts by the convergence of its north

and south shores at Soldiers Point, where the normal width of from 3 to 5 miles is reduced to less than a quarter of a mile. The narrowing at this point is due to the presence of massive acid lava flows forming a ridge striking approximately N.N. West and S.S. East.

Before the subsidence took place, which produced Port Stephens, this ridge formed the divide between the watersheds of the Karuah and Myall Rivers. The drowning submerged a col in this one-time divide and allowed the waters of the Karuah River to flow into the eastern part of Port Stephens, which is the drowned valley of the Myall River. Previous to this, the Karuah River continued its southern course and joined up with the Hunter River system. To-day there are only low-lying alluvial flats between the western part of Port Stephens and the Hunter River estuary.

Throughout the whole district raised beaches occur, both on the sea coast and on the coast of Port Stephens itself. These latter, at many places, form distinct contour lines around the water front. An interesting raised beach is that which occurs at the north end of Morna Point. A photo of this beach is given in Plate XIV. Here well-rounded boulders of Rhyolite occur up to an elevation of 20 feet above present high water mark. There are also included pebbles of chert, pumice and kerosene shale. Large trees (eucalypts and banksias) are now growing on this raised beach.

The Rhyolite boulders, particularly those at the back of the old beach, are quite kaolinised, indicating the long lapse of time since they were placed there. Associated with the pebbles are numbers of large gasteropod and pelecypod shells, also for the most part quite decayed.

B. General Geology.

The rocks of this region belong mainly to the Kuttung Series of Carboniferous age; but, as already pointed out, these are covered to a considerable extent with recent superficial deposits. The general structure is that of a large plunging anticline, the horizontal axis of which pitches to the south. The rocks consist mainly of a series of massive lava flows, apparently separated from one another by weaker sedimentary strata. A section of these strata, in descending order, is as follows:—

	Thickness
Cherts and Tuffs (thickness unknown).	
Rhyolite flow (Morna Point Flow)	300 feet
Cherts (with *Rhacopteris*)	10 „
Tuff	30 „
Tuffaceous Conglomerate with small Rhyolite Flow (No. 2 flow)	355 „
Tuff	45 „
Rhyolite (No. 1 flow)	165 „
Tuffaceous Sandstone with fossil plants	600 „
Conglomerates and tuffs	800 „
Strata (no outcrops)	1,130 „
Toscanite Flows	500 „
Strata (no outcrops)	580 „
Toscanite Flows	400 „
Strata (no outcrops)	750 „
Toscanite (Nelson's Head Flow)	200 „
Conglomerate (with large boulders)	300 „
Andesite (No. 2 flow)	20 „
Conglomerate	30 „
Andesite (No. 1 flow)	100 ±„
Conglomerate (thickness unknown).	
Total ..	6,315 feet

The above figures must be taken as mere approximations as the incompleteness of the section makes the determination of actual figures impossible.

1.—The Andesites.

Nelson's Bay.

A well-defined flow of andesite (No. 1 flow) outcrops at intervals along the south shore of Port Stephens from Nelson's Bay to Corlette Point. This flow strikes about E. 20° N. and dips S. 20° E. at an angle of about 20°. The section adjoining the steamer jetty at Nelson's Bay, in descending order, is as follows:—

Conglomerate (with very large boulders) ..	100 feet
Andesite (No. 2 flow)	20 „
Conglomerate	30 „
Andesite (No. 1 flow)	100 „

Here the No. 1 andesite flow occurs right at sea level. The lower part is quite glassy, the glassy phase merging upwards into a lithic variety. The rock is a hornblende-pyroxene-andesite and is described in detail in a later section. The full thickness of this flow is not exposed, but it is at least 100 feet thick. The No. 2 flow is similar in character to the No. 1 flow. The lower andesite gives a continuous outcrop westwards from the jetty to the eastern end of Dutchman's Beach, then follows a sand flat, followed by a smaller outcrop at the western end of Dutchman's Beach. From this point westwards nothing but sand can be seen until Corlette Point is reached. Here the andesite flow may be seen resting upon a bed of conglomerate, both dipping southwards. It is uncertain as to whether this flow represents the No. 1 or the No. 2 flow at Nelson's Bay. If it is the No. 2 flow, then the No. 1 flow will be found here, not far below sea level, underlying the conglomerates above referred to.

Tomaree or *South Head.*

A small outcrop of andesite occurs here at sea level on the west side of the headland, striking north and south, and dipping easterly. It is immediately overlaid by a massive toscanite flow.

Yacaaba Headland (North Head).

Here also, just at sea level, is an andesite flow outcropping along the northern shore of the headland. This flow strikes E. 25° N. and dips S. 25° E., with a massive toscanite flow resting immediately above it. As the andesite flow extends below sea level, it is impossible to determine its true thickness. An interesting feature here is the occurrence of a bar of toscanite cutting across the andesite flow and containing fragments of andesite. The andesite occurring at the three abovementioned localities are probably all parts of one and the same flow, but it is difficult to reconcile the strike at Tomaree with that at Nelson's Bay and at Yacaaba headland.

Point Stephens Headland.

Point Stephens headland is an island consisting entirely of andesite, joined to the mainland by a narrow sandspit which is awash at high tide. A small outcrop of Andesite also occurs on the opposite mainland at the northern end of Fingal Head. This andesite is similar in character to that occurring at Nelson's Bay. If part of a flow, it is higher in the series than the Nelson's Bay flow. The shape of the outcrop, however, and the relation to the adjoining rocks is not suggestive of its being a typical sheet. We suggest that it may be, probably, an andesite lava cone extruded at the same time as the Nelson's Bay flow, and afterwards surrounded and covered by the later toscanite and rhyolite flows and their associated sedimentary rocks, but the available evidence does not admit of proof one way or the other.

A similar andesite volcanic cone of Kuttung age, surrounded and covered by younger strata, and since partly re-exposed by the partial removal of the overlying strata, has been recorded as occurring at Blair Duguid, in the Hunter River Valley.[5]

2.—The Toscanites.

Numerous and massive flows of toscanite occur throughout the district, but as the outcrops of these are isolated from one another by sand flats or by water, and as there has been, in places, considerable displacement of outcrops by faulting, it is somewhat difficult properly to correlate the various outcrops. There would appear to have been at least two distinct toscanite flows or groups of flows. These two groups are referred to respectively as (*a*) the Nelson's Head-Yacaaba flow and (*b*) the Soldiers Point-Ghan Ghan group of flows.

(*a*) *The Nelson's Head-Yacaaba Flow.*

Nelson's Head.

The whole of Nelson's Head consists of toscanite extending from low water mark to the top of the hill on which the lighthouse stands. The strike is about E. 20° N. and the dip to the south. On the northern face of the headland the rock at sea level is entirely glassy for a thickness of from 10 to 15 feet. Upwards, this glassy phase merges into a lithodal phase, the latter continuing to the top of the hill. The base of the flow is below sea level, but the thickness is not less than 100 feet.

Fly Point.

This is a low headland occurring to the west of Nelson's Head. A similar occurrence of toscanite occurs here, with a glassy selvedge at the base of the flow, but this glassy phase is less well marked, and the flow, as a whole, is not so thick, much having probably been removed by denuda-

tion. The base of the flow here is, however, exposed, and at low water a bed of conglomerate may be seen underlying the toscanite. This is similar in character to the conglomerate which overlies the andesite at Nelson's Bay. A dip fault probably occurs between Fly Point and Nelson's Head, which has displaced the strata to the north on the east side of the fault.

Yacaaba Headland (North Head).

The sequence of strata in this headland is given in fig. 1. It will be seen that the Toscanite flow here rests directly upon the andesite flow and has a thickness of about 1,000 feet. The toscanite flow here has a glassy selvedge at its base similar to that at Nelson's Head. The most interesting feature here is a dyke or neck of toscanite

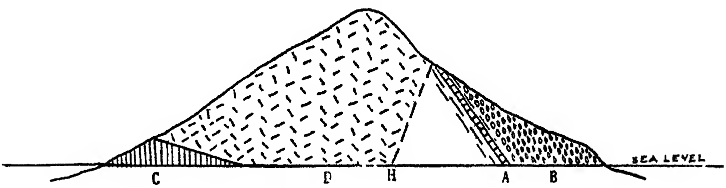


Fig. 1.—Sketch section through Yacaaba Headland. A, Limestone with associated Tuffs; B, Conglomerates; C, Andesite; D, Toscanite. H, Fault.

which cuts through the underlying andesite flow. In the toscanite are numerous rounded fragments of a more basic rock which is much altered but which appears to have been derived from the Andesite. Whether neck or dyke, this would undoubtedly appear to be an opening through which the overlying toscanite found its way to the surface.

As has already been pointed out, this toscanite overlies the andesite at Yacaaba and Tomaree. No andesite is exposed at Nelson's Head or Fly Point, but may well be below sea level at these points.

No outcrop of this toscanite flow can be found immediately above the andesites which extend from Nelson's

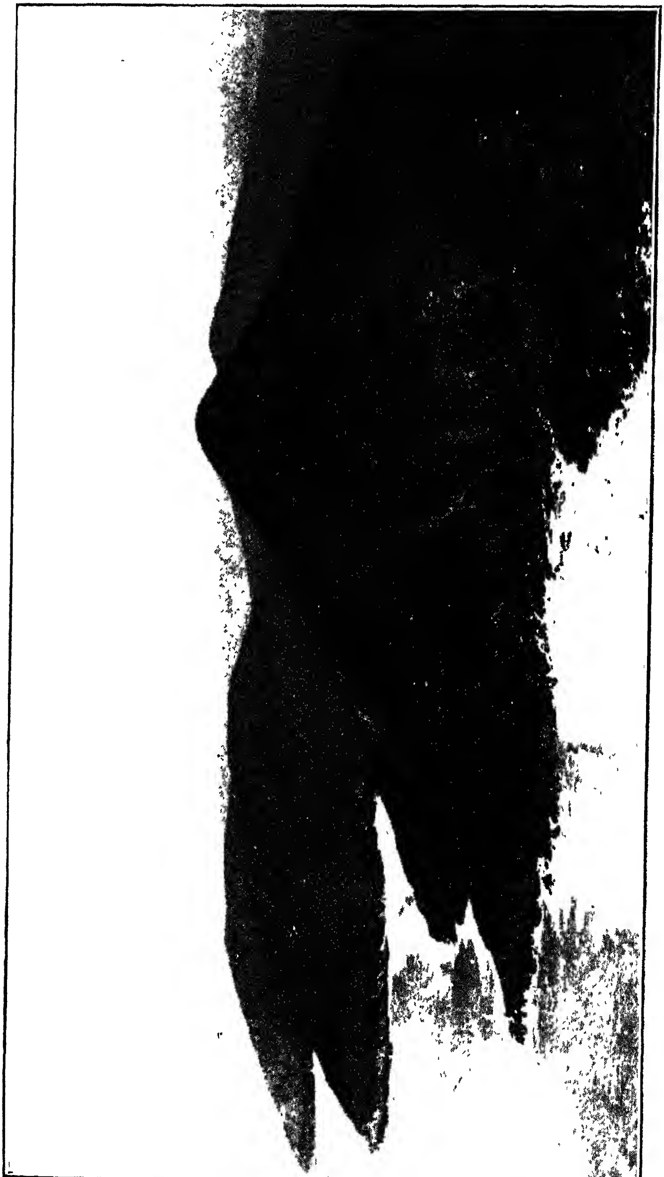
Bay to Corlette Point. The flow may have pinched out in this direction, or if it occurs, its outcrop is covered by recent sand deposits. The fact that the flow is about 1,000 feet thick at Yacaaba Head and only about 40 feet thick at Fly Point suggests that it thins rapidly in a westerly direction. The great thickness of toscanite at Yacaaba may, of course, be due to the coalescence of the Nelson's Bay flow with some of the overlying toscanite flows of that locality.

(b) *The Soldiers Point-Ghan Ghan Toscanites* (*No.* 2 *Belt*).

Lying to the south of Nelson's Bay and extending from the sea coast westwards to Scamander Bay there is a belt of isolated hills all consisting of toscanite. The strike of this line of hills is approximately east and west. After crossing Scamander Bay, this toscanite belt is picked up again on the western side of the bay at Round Head, and continues from there in a north-north-west direction to Soldiers Point, as may be seen from the map. The various islands adjacent to Soldiers Point, including Middle Island, consist of the same rock. Toscanite also occurs on the north shore of Port Stephens opposite to Soldiers Point, very massive outcrops occurring here on either side of Fame Cove. This great belt of Toscanite undoubtedly includes a number of separate lava flows. At its eastern end the double line of hills suggests at least two massive lava flows. Throughout the whole belt the rock from all the outcrops is similar in character and looks like a typical Quartz-Porphyry. It also closely resembles the toscanites occurring at Nelson's Head and at North Head. The numerous outcrops in this toscanite belt are separated from one another by sand dunes and sand flats, and no associated sedimentary strata are visible, so that no direct observations of either dip or strike could be made.

Fig. *a*.
Raised Boulder Beach (Present day beach centre-left), Morna Point.

Fig. *b*.
Raised Boulder Beach, Morna Point.



Toscanite Hills, Sea-coast south of Tomaree Head.

3.—The Rhyolites.

These lava flows outcrop in the southern part of the area mapped and form a belt whose outcrop curves sympathetically with that of the No. 2 toscanite belt. Outcrops occur on the sea coast (*a*) at Fingal Head and (*b*) at Morna Point, and further outcrops occur at Bob's Farm on the east side of Tilligherry Creek, and at The Gibbers on the west side of Tilligherry Creek. Snapper Island, in the west part of Port Stephens, is probably a continuation of this belt.

Fingal Head.

At the northern end of Fingal headland there occurs an outcrop of andesite, previously referred to. Immediately overlying this is a rhyolite lava flow, the outcrop extending from here to the southern end of Fingal Head, a distance of about 160 chains. The actual thickness of this flow cannot be measured, but it is something more than 200 feet.

Morna Point.

The outcrop here is exactly similar to that at Fingal Head, and this outcrop appears to have been separated from that at Fingal Head by a large dip-fault which has heaved the strata on its east side to the north. The rock both here and at Fingal Head is indistinguishable in hand specimens from the toscanites already referred to. At Morna Point the rhyolite flow appears to be dipping a little east of south.

Bob's Farm (Fenningham's Island).

Between here and Morna Point is an extensive swampy sand flat with no outcrops. The outcrop at Bob's Farm occurs at the western edge of this flat and at the eastern side of Tilligherry Creek, and the rock here has been quarried for road-making purposes. At this locality the

rhyolite is underlain by well-stratified tuffs and cherty shales, the latter containing the fossil plant *Rhacopteris*. Underlying this again is another rhyolite flow.

The Gibbers.

This locality occurs on the other side of Tilligherry Creek, immediately west of Bob's Farm, and gives one of the best geological sections of the district. (See fig. 2.) The details of this section in descending order are as follow:—

	Thickness.
Rhyolite (No. 3 flow)	300 feet
Tuffs	15 ,,
Cherty shales with *Rhacopteris*	10 ,,
Tuffs and Conglomerates	130 ,,
Rhyolite (No. 2 flow)	15 ,,
Tuffs and Conglomerates	200 ,,
Tuffs	40 ,,
Rhyolite (No. 1 flow)	160 ,,
Tuffaceous sandstones with fossil plants	600 ,,
Conglomerates	800 ,,
Total thickness ..	2,270 feet

It will be seen that there are three distinct rhyolite lava flows here. The whole succession of strata at this locality is very similar to that which occurs in the Paterson district. The top rhyolite flow would be the equivalent of that which occurs in the railway cutting at the Paterson railway station.

4.—The Sedimentary Rocks.

The Burindi Series.

Strata of Burindi (Lower Carboniferous) age are extensively developed in the Pindimar district on the northern side of Port Stephens, but these will not be described here; the occurrence of probable Burindi strata

occurring at Yacaaba headland might, however, be referred to here. These are shown in the section in fig. 1. These strata strike E. 35° N., have a steep dip, and consist of a massive bed of conglomerate overlying a thin bed of tuffaceous limestone. The limestone is very impure, contains crinoid stems, and is lithologically similar to limestones which occur in the Burindi series in other parts of the district. The conglomerates which overlie the limestone are very massive and are crowded with pebbles from 6 to 8 inches in diameter. This conglomerate may possibly be the equivalent of the Wollarobba conglomerate which. in another part of the district, occurs at the base of the Kuttung series. Strike faulting has brought these beds against the toscanite, which is relatively higher in the series.

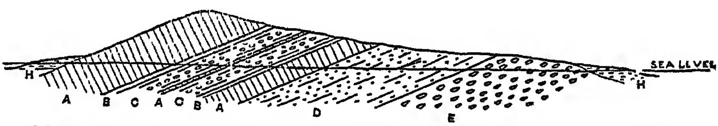


Fig. 2.—Sketch Section at "The Gibbers." A, Rhyolite; B, Cherty Shales; C, Tuffs and Conglomerates; D, Tuffaceous Sandstones; E, Conglomerates; H, Alluvium.

The Nelson's Bay Conglomerates.

These are associated with the Andesites which occur at Nelson's Bay, already referred to. They show very little stratification and contain well-rounded boulders of all sizes up to 3 feet or even more in diameter. These boulders consist mainly of granites of various kinds, Quartz-Porphyry and Felspar-Porphyry. The material in which the boulders are embedded is very largely tuffaceous. At Corlette Point similar conglomerates occur, associated with the andesite there, but the boulders are relatively fewer in number. These Nelson's Bay conglomerates are very similar in their lithological characters to the conglomerates which are associated with the andesites on the same horizon in the Kuttung series at Martin's Creek, near Paterson.

The Gibbers.

Particulars of the sedimentary rocks occurring here have already been given when referring to the rhyolite of the same locality. The occurrence in these of the fossil plant *Rhacopteris* (*Aneimites*) *inequilatera* proves that those strata belong definitely to the Kuttung series. These strata, with their associated rhyolite flows, correspond in character and horizon with what one of us (C.A.S.)[3] has previously described as the Mt. Johnson series in the Paterson district, and they are quite similar to them in their lithological characters.

The Anna Bay Bores.

Some years ago several bores were put down in the southern part of this region for the purpose of prospecting for coal. Details of the strata penetrated by these bores are given by Sir T. W. E. David in his monograph on the Hunter River coalfield.[1] No. 1 bore, which is $2\frac{1}{2}$ miles west of Morna Point, after passing through 192 feet of recent alluvial deposits, penetrated 126 feet into a Quartz Felspar-Porphyry. This is evidently the Morna Point Rhyolite flow; the angle of its dip is given as 23°. The No. 2 bore, after passing through 192 feet of recent deposits, penetrated 257 feet of cherty shales alternating with tuffaceous conglomerates and tuffaceous sandstones. These strata dip S.S.W. at an angle of 22° and apparently overlie the top rhyolite flow. The cherts contain the fossil plant *Rhacopteris.*

5.—Geological Structure.

Reference to the map will show that the outcrops of the Kuttung Series form a great curve, convex to the south. In the western part of the area the strike of the strata is approximately N.N.W., and the dip westerly; from Corlette Point to Nelson's Bay the strike is nearly east and west, and the dip southerly, while in the eastern part

of the area the strike is E. 20° N. to E. 30° N., and the dip S. 20° E. to S. 30° E. It is evident, therefore, that the general structure is that of a great plunging anticline, the axis of which strikes approximately north and south, with a pitch to the south. This conforms to the general geological structure of the carboniferous formation right along the southern margin of New England from the Pacific coast to Scone.

The probable existence of faults has been referred to (*a*) at Nelson's Head between West Point and Fly Point, (*b*) between Fly Point and Nelson's Head, and (*c*) between Morna Point and Fingal Head; on the accompanying geological map these faults have been joined up as shown, but, of course, this joining up is, to a large extent, conjectural. These faults are all dip faults. The existence of a strike fault has been suggested as occurring at North Head, as shown in fig. 1. This strikes about E. 30° N.

II.—Petrography.

The Kuttung lava flows fall naturally into three distinct groups: (*a*) the andesites, (*b*) the toscanites, (*c*) the rhyolites, extruded (with perhaps one exception) in that order.

1.—The Andesites.

These are all hornblende-pyroxene-andesites, and they may be divided into two varieties: (*a*) the glassy variety, (*b*) the lithoidal variety.

a. The Glassy Andesite.

This occurs at West Point, Nelson's Bay, where it is found at the base of the lowest andesite flow; there is a similar occurrence at Corlette Point.

Megascopic Characters.—The fresh rock is black in colour with a resinous lustre, and shows abundant phenocrysts, of felspar, hornblende and pyroxene.

Microscopical Characters.—The ground mass shows well-marked flow structure, with some spherulitic structure present in places, and in this groundmass is set an abundance of phenocrysts of plagioclase, hornblende and pyroxene, with a few crystals of quartz and biotite; the two latter are very rare. Occasional small areas occur which show hyalopilitic structure and smaller phenocrysts than in the average rock. In such areas the felspars are lath-shaped, with their long axes in the direction of flow. The plagioclase in general is tabular in habit and almost quite fresh with a composition close to Ab_2 An_3. The hornblende also is quite fresh and frequently twinned. The pyroxene is less abundant than the hornblende. It occurs both as occasional phenocrysts and as quite small crystals included in the felspars. It is weakly pleochroic and has parallel or low extinction angles. It appears to be hypersthene. The iron ores are moderately abundant and occur both as inclusions in the larger phenocrysts and in the groundmass. An occasional small crystal of biotite may be seen, but this mineral is rare. Apatite is present as occasional small needles included in the felspar. In spite of the fact that the norm shows 31.2 per cent. of quartz, only very few phenocrysts of this mineral have been seen in the slides.

A noticeable feature of the glassy andesites is the remarkable freshness of all the phenocrystic minerals. This is in marked contrast with the condition of the similar minerals in the lithoidal variety of andesite.

b. The Lithoidal Andesites.

These Andesites are similar in their characters from all the localities from which they have been found in the Port Stephens district.

Megascopic Characters.—In hand specimens the rock is dark blue in colour, showing abundant phenocrysts of

felspar, with less abundant phenocrysts of black ferro-magnesian minerals.

Microscopic Characters.—The groundmass is cryptocrystalline and very fine-grained. Traces of what appears to have been a flow structure occur in places, but there is no evidence to suggest that the groundmass, as a whole, was originally glassy.

The following minerals are present in order of abundance:—(1) Plagioclase, (2) Hornblende, (3) Pyroxene, (4) Magnetite.

The plagioclase phenocrysts are tabular in habit, and abundant. Albitization is well marked, alteration having taken place along irregular lines and cracks. Occasionally some chloritization has taken place, but is not common. The hornblende shows undoubted resorption, and the margins of the crystals all have a very dark zone, probably due to the development of minute crystals of iron oxide. This is particularly noticeable in the microslides of the andesite from North Head. The pyroxene crystals are entirely replaced by chlorite, and it is now impossible to determine their true nature. An occasional phenocryst of quartz has been seen in some of the slides.

An analysis of each of the two varieties of andesite is given in Table I; the specimens selected for analysis came from West Point, Nelson's Bay. An important difference between the two rocks as shown by the analyses is in the relative proportion of the alkalies and lime. This is shown in the following table:—

	Port Stephens.		Martin's Creek.	
	Glassy Variety	Lithoidal Variety.	Glassy Variety.	Lithoidal Variety.
CaO	6.38	4.28	4.11	3.14
Na_2O	2.20	3.39	3.55	4.41
K_2O	0.66	3.02	1.72	3.52

The lower percentage of alkalies in the glassy rock is very marked. This is particularly so in the case of the potash, and, in order to make sure that no mistake had been made, the potash and soda in the glassy rock were re-determined. The percentage of lime, on the other hand, is noticeably higher in the glassy rock. The corresponding constituents of the glassy and lithoidal andesite from Martin's Creek[4] are given for comparison. These show a similar variation between the two rocks, but not to such a marked extent.

The norms of the two Port Stephens rocks, as calculated from the analysis, are as follows:—

	Glassy Variety.	Lithoidal Variety.
Quartz	31.20	19.86
Orthoclase	3.33	17.79
Albite	18.34	28.82
Anorthite	29.74	17.79
Femic Minerals	7.92	8.01
Iron Ores	4.14	4.17

On account of its alkaline content the glassy rock gives a much lower percentage of albite and orthoclase than does the lithoidal variety, and a correspondingly higher percentage of quartz.

2.—The Toscanites.

These, like the andesites, fall naturally into two varieties: (*a*) a glassy variety, (*b*) a lithoidal variety.

a. The Glassy Toscanite.

This has been found only at the base of the oldest toscanite flow, and in each of the three localities at which it has been found, namely, Fly Point, Nelson's Head and Yacaaba Head, it occurs just at sea level. The occurrence at Nelson's Head can be taken as typical of all three localities, and it is this rock which has been analysed.

Table 1.
Analyses of Port Stephens Rocks, by W. A. Greig.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
	Andesite Glass	Andesite	Toscanite Glass	Toscanite	Toscanite	Toscanite	Rhyolite	Rhyolite
SiO_2	63·17	63·92	71·72	73·90	73·64	73·90	73·96	74·74
Al_2O_3	15.10	15 37	11·50			11·95	12·65	11·89
Fe_2O_3	2·20	2·90	2·30			1·70	1·85	1·50
FeO	2·16	2·34	0·63			0·99	0·40	0·27
MgO	2·35	2·60	0·41			0·55	0·50	0·83
CaO	6·38	4·28	2·56			1·50	0·64	0·74
Na_2O	2·20	3·39	3·40	3·50	3·42	3·10	3·18	2·96
K_2O	0 66	3·02	2·53	4·04	4·59	4·74	5·07	5·23
H_2O (100°c)	0·47	0·41	0·35			0·21	0·45	0·60
H_2O (100°c+)	4·73	1·65	4·51			1·37	1·33	1·14
CO_2	Absent	Absent	Absent			Absent	Absent	Absent
TiO_2	0 50	0·05	0·15			0·20	0·20	0·17
ZrO_2	Absent	Absent	Absent			Absent	Absent	Absent
P_2O_5	0·14	0·16	0·03			0·05	0·07	0·02
SO_3	Absent	Absent	0·06			Absent	Absent	0·02
Cl	0·11	0·07	0·10			Trace†	Trace†	0·10
F	Absent	—	Absent			—	—	Absent
S (FeS_2)	,,	Absent	,,			Absent	Absent	,,
Cr_2O_3	,,	,,	,,			,,	,,	,,
NiO+CoO	,,	,,	,,			,,	,,	,,
MnO	0·10	0 07	0·11			0·06	Trace†	Trace†
BaO	0·03	0 04	0·05			0·06	0·04	0·07
SrO*	Absent	Absent	Absent			Absent	Present	Absent
Li_2O	Present	,,	Present			,,	Absent	Present
V_2O_3	Trace†	,,	Absent			Trace†	,,	Absent
CrO	Absent	,,	,,			Absent	,,	,,
	100·30	100·27	100·41			100·38	100·34	100·28
Less O=Cl	·02	0 1	0·2					·02
	100·28	100·26	100·39			100·38	100·34	100·26
Sp. Gr.	2·524	2·694	2·443			2·613	2·611	2·600

*Spectroscopic Reaction. †Less than 0·01%

Localities.—I. and II., West Point, Nelson's Bay; III., Nelson's Head; IV., Fly Point; V., Nelson's Head; VI., Round Head; VII., Fingal Head; VIII., Morna Point.

Megascopic Characters.—The rock is black in colour when fresh, with a vitreous lustre, and contains an abundance of phenocrysts of quartz and felspar.

Microscopic Characters.—The groundmass is quite glassy and displays a well-marked flow structure. In this groundmass there is set an abundance of large phenocrysts of quartz, plagioclase, orthoclase and biotite. The quartz phenocrysts are relatively large, show marked corrosion, and are frequently cracked and broken, but show no strain structure. The plagioclase is tabular in habit, is perfectly fresh and free from alteration, and displays well-marked albite twinning. It is an acid oligoclase with a composition of about Ab_{10} An_{3}. Some of the plagioclase crystals are fractured. The orthoclase is quite fresh, but is less abundant than the plagioclase. Biotite is not nearly so abundant as the other minerals, and is also quite fresh.

b. The Lithoidal Toscanite.

This is the dominant lava of the district, individual flows ranging up to at least 1,000 feet in thickness. From all the many occurrences the rock is quite similar both in its megascopic and microscopical characters.

Megascopic Characters.—The colour of the mass varies from pale pink to slate blue, according to the state of preservation; except where the rock has been quarried, it is difficult to obtain really fresh samples. This rock is crowded with phenocrysts of quartz and felspar, the latter usually being red or pink, or more rarely white. In hand specimens the rock looks like a typical quartz-phorphyry.

Microscopical Characters.—The groundmass is variable, usually cryptocrystalline to glassy, and some specimens, notably some from Soldiers Point, have a micro-crystalline groundmass which consists of an aggregate of small crystals of quartz and felspar, sometimes showing micrographic

structure. Flow structure similar to that which occurs in the glassy variety is present in many specimens, and in some of the slides the rock appears to have been originally glassy and to have subsequently become more or less devitrified. At Nelson's Head there is no sharp line of demarcation between the two varieties, the glassy variety merging upwards into the lithoidal variety. The phenocrysts consist of quartz, plagioclase, orthoclase and biotite similar to those occurring in the glassy variety, except that all the minerals other than quartz show considerable alteration. The orthoclase is much kaolinized. The plagioclase exhibits saussuritization and, much more rarely, kaolinization; in some slides the centre zones of some few crystals have been replaced by chlorite, but this is not common; the biotite is commonly bleached. The question as to whether the alteration of the felspars in the lithoidal lavas of the Kuttung series is deuteritic or not has been fully discussed by G. D. Osborne[4] when describing these lavas from the Paterson district, and this question, therefore, will not be discussed here; but it is worthy of note that the alteration of the felspars in the lithoidal toscanites is in marked contrast to their freshness in the glassy toscanites. Complete analyses of the two varieties of toscanite are given in Table I, together with two partial analyses. It will be seen that the glassy variety is lower in soda and potash, but higher in lime than in the lithoidal variety, but it is only in the case of the potash that the difference is well marked. The norms of the two varieties, as calculated from the analyses are as follows:—

	Glassy Variety.	Lithoidal Variety.
Quartz	36.96%	34.44%
Orthoclase	15.01%	27.84%
Albite	28.82%	26.20%
Anorthite	8.62%	4.73%
Femic Minerals	2.74%	2.56%
Iron Ores	2.96%	3.00%

It will be seen that in both cases the plagioclase (oligoclase) preponderates over the orthoclase. The magmatic name of the glassy variety in the American classification is Tehamose. It might be pointed out, however, that this rock falls almost on the border line which separates the orders columbare and britannare in that classification, and consequently it is very close to toscanose, the magma to which the lithoidal variety belongs. Both magmas are domalkalic and sodi-potassic. Some petrologists would prefer to call these rocks Dellenites on account of the acid nature of the plagioclase. The lithoidal variety is not far removed from the Rhyolites (Liparose).

3.—The Rhyolites.

The main rhyolite flow (No. 3 flow) occurring at Fingal Head, Morna Point and Tilligherry Creek is indistinguishable in hand specimens from the toscanites. Under the microscope also the two rocks are quite similar, the only noticeable difference being a higher proportion of orthoclase in the rhyolites. Two analyses of the rhyolite have been made, one taken from near the base of the flow at Fingal Head, the other taken from near the top of the flow at Morna Point. These analyses are shown in Table I. The norms, as calculated from these two analyses, are as follows:—

	Fingal Head.	Morna Point.
Quartz	34.14%	34.86%
Orthoclase	29.46%	30.58%
Albite	27.24%	25.15%
Anorthite	3.05%	3.61%
Femic Minerals	2.89%	2.10%
Iron Oxides	1.73%	1.92%

In the American classification the magmatic name would be Liparose, almost on the border line between Liparose and Omeose. In comparing these norms with that of the

lithoidal toscanite, the only difference is a small increase in the proportion of orthoclase as compared with plagioclase in the rhyolites.

The other rhyolite flows occurring below the main flow at Tilligherry Creek have not been analysed, no specimens sufficiently fresh for that purpose being available. The No. 1 flow, which is pink in colour, consists mainly of a felsitic groundmass through which are scattered a few felspar phenocrysts. In the microslides the groundmass is seen to be cryptocrystalline, but part, if not all, of this groundmass appears to have been originally glassy, with well-marked flow structure. The few felspar phenocrysts are much altered and consist mainly of plagioclase, although orthoclase is also present. The true nature of this rock has not been determined, it has only been placed with the rhyolites provisionally. The No. 2 flow from Tilligherry Creek, although somewhat finer grained, is in all respects similar to the main rhyolite flow (No. 3 flow), and does not need separate description.

4.—Sequence of Eruption of the Flows.

This is left somewhat in doubt owing to the uncertainty as to the true nature of the mode of occurrence of the andesite which occurs at Stephens Head. As has already been pointed out, this occurrence may be either:

(*a*) A lava cone of the same age of extrusion as the andesites at the base of the series, and which was subsequently surrounded and finally submerged by the later toscanite and rhyolite flows, or

(*b*) A lava flow poured out after the toscanites, but before the rhyolites.

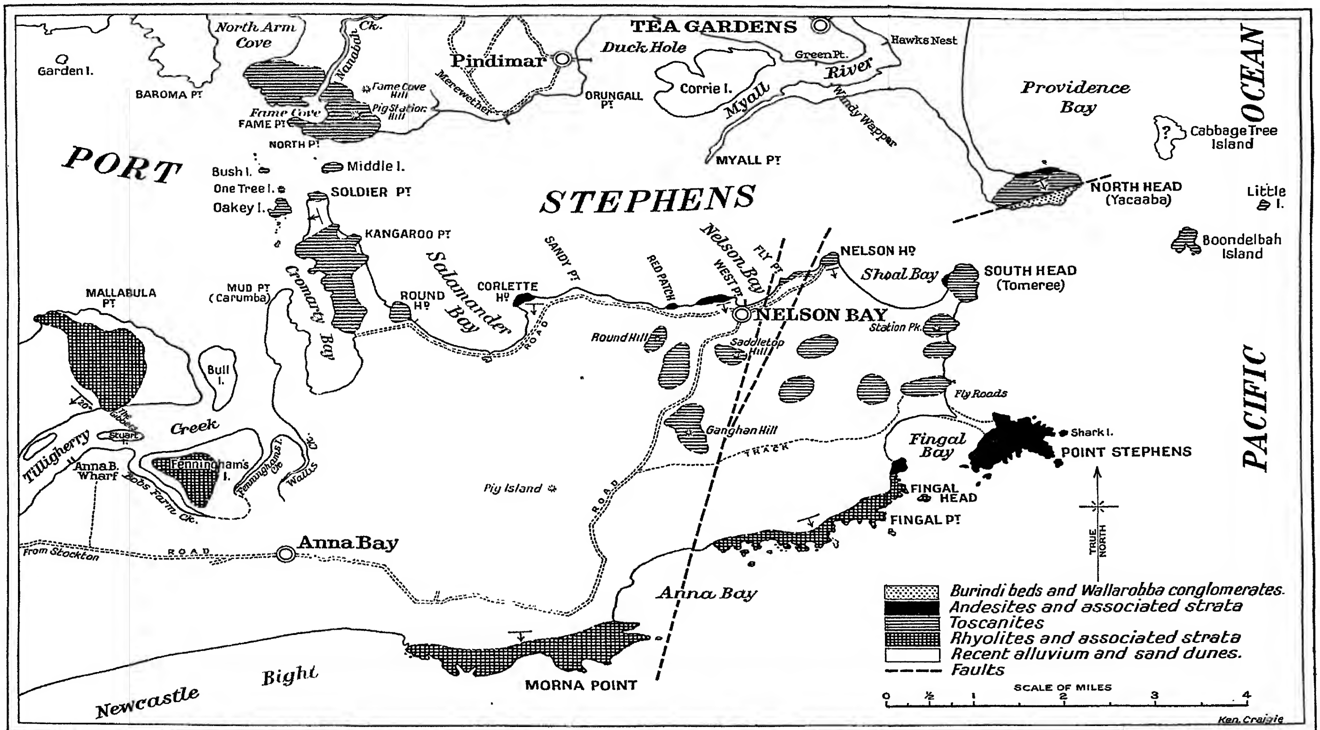
If the first interpretation is the correct one, then we have in the Kuttung Series of the Port Stephens district a series of lava flows beginning with andesites, followed

by toscanites and a final outpouring of rhyolites. The rocks analysed are arranged in this order in Table I, and an examination of the analyses will show the following points of interest:—

1. The silica percentage shows a progressive increase ranging from 63.17 per cent. to 74.74 per cent.
2. The soda percentage remains fairly constant, but decreases slightly towards the end of the series.
3. The potash shows a progressive increase ranging from 0.66 per cent. at the beginning of the series to 5.23 per cent. at the end of the series.
4. The basic oxides (CaO, MgO, and FeO) all show progressive decreases from the beginning to the end of the series.

These facts would indicate that at the beginning of the Kuttung vulcanicity in this district the feeding reservoir contained a magma of andesitic composition, but that, as a result possibly of gravitational sinking of the more basic minerals, as cooling and crystallisation progressed, the magma in the upper part of the reservoir became progressively more acid, and thus the eruption of andesites was followed later by the eruption of toscanites, and these later were followed by the eruption of the rhyolites. It is worthy of note that, soon after the close of the Kuttung period of vulcanicity, an extensive series of basic lavas (natrolite basalt) was erupted in this same district and forms part of the Lower Marine Series which overlie the Kuttung Series. These basalts may be taken to represent the basic portion which accumulated in the lower part of the magma reservoir, whose final eruption completed the cycle.

If, on the other hand, the andesites of Stephens Head represent a lava flow poured out after the toscanites, then



Geological Map. Port Stephens District.

we get the following order of extrusion for the Kuttung lavas: (1) andesites, (2) toscanites, (3) andesites, (4) rhyolites. This is a similar order of extrusion to that which occurs in the Kuttung Series at Eelah. So far as the Port Stephens area, however, is concerned, we are of opinion that interpretation (*a*) is the correct one and that the lavas became progressively more acid as they were erupted.

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THE OUTBREAK OF SPRINGS IN AUTUMN.

By R. H. CAMBAGE, C.B.E., F.L.S.

(Read before the Royal Society of New South Wales, Sept. 5, 1928.)

The outbreak of springs in New South Wales between the months of February and June usually passes unnoticed excepting during drought seasons, when various reports of the occurrence are made to the press; but if an increased flow of water is observed in any of the streams after even a very slight fall of rain, this increase is generally attributed to the rainfall and no remarks are made. The theory advanced in this paper is that at least ninety per cent. of these outbursts or stimulated flows which occur when no rain falls are caused by a decrease in evaporation or lowering of atmospheric temperature, and that the phenomenon is in evidence after the heat of summer has passed, or after a sudden drop in temperature for a few days, but is more noticeable in the absence of rainfall.

A short note which I contributed on the subject was published in "The Surveyor" in June, 1897,* and in September, 1897, the late W. E. Abbott read a valuable paper on the question before this Society.† In both of these contributions the cause of the outbursts was attributed to diminishing evaporation. The object of the present paper is to record the result of further investigations into the matter.

* "The Surveyor," 1897, 10, No. 6, 144.

† This Journal, 1897, 31, 201. See also "Report on the Water Resources of the Hunter Valley," 1908, by J. B. Henson, Assoc.M.Inst.C.E. (Hunter District Water Supply and Sewerage Board). The report was received after this paper was read.

My first observation on this subject was made in December, 1890, where there was a small swamp in the Walcha district, and every morning a little stream was flowing freely from it, but by each evening all water had disappeared from the tiny strêam. I have noticed the same feature many times since then, and similar observations have been made by bushmen on innumerable occasions. During a dry period in 1897, my assistant, Mr. R. G. Wilson, drew my attention to the fact that all the cases of increased flow which we had noticed during our surveying operations in the Bathurst to Harden district originated in swamps.

It does not appear that barometric changes of pressure cause these outbursts of springs, for, as Mr. Abbott points out, this would require a high pressure at the source of the spring and a low pressure at its outlet. It would not be possible to get this difference of pressure in such a short distance as that comprised in the length or width of one of these water-supplying swamps, which are often only a few hundred yards or, at most, a few miles in extent.

The theory that the dry weather cracks the ground and releases impounded water is by no means universally accepted, because in an ordinary case the ground will not crack while it remains moist. Mr. Abbott cites the case of a surface dam, and states that while it contains any water the outside of the dam will not crack, even in dry, hot weather.

On the other hand, Mr. E. T. Webb, of Bathurst, wrote to me in April, 1923, as follows:—"In a dry time some years ago a crack came in the ground on the side of a hill about 8 miles from the town, and after a time moisture came up through the crack, and when the moisture had softened the ground the water commenced to run—this in

hot weather, and in a place where there had been no spring before."

I do not know the local conditions surrounding this case, but it is conceivable that a slight earth movement or partial landslide on the side of a hill might result in releasing some water, or cause its course to be diverted.

Mr. Webb also wrote: "Now my theory is this, that in different localities the nature of soil and subsoil is different and therefore different causes operate. Here it is principally granite country with clay subsoil; hence, as a spring gets weak the small particles of granite which are coming along the channel gradually stop the opening until no water will percolate through; the water then commences to accumulate at the back until the pressure is sufficient to clear the opening."

No doubt something of this nature happens at times, but only in a small way, and is of a local nature; whereas an increase in the flow of various streams appears to be more or less of a regular character during some portion of the autumn. In reply to my question in March, 1923, the manager of Springfield, in the Orange district, stated that the water generally increases in Lewis Ponds Creek in or about May, even if no rain falls.

I was informed that without any rain having fallen the water commenced to flow in Molong Creek near the town of Molong, on the 9th or 10th April, 1923. Prior to this the creek had stopped running owing to dry weather.

Springs and their Variation.

On the western slopes of New South Wales, where many of these springs occur, there are three different sets of conditions. One is in the northern portion where the steeply-dipping rocks convey the rain-water westerly to a

great depth, where it is overlain by impervious strata, and impounded. This artesian water is reached by boring, when it comes to the surface as the result of pressure.

The second condition is found towards the foot of the western slopes, where rain-water disappears by soakage in fairly level country with a considerable amount of alluvium, and this water may not find an outlet, but as sub-artesian water may be brought to the surface by windmills or other methods of pumping.

The third case, which is that now under consideration, is where the rain or snow falls on elevated country. and then finds its way into the soil which acts as an underground reservoir, which in ordinary years is kept practically full. The small outlets through which the water escapes are called springs, and while there is a quantity of water in the soil or reservoir these springs may continue to flow, even if no rain falls. Near the outlet the ground becomes spongy, and the water, to some extent by capillary attraction, rises to the surface and forms swampy areas of various dimensions. As the summer advances and evaporation increases, there often comes a time when the evaporation, which may continue day and night, claims all the water on the surface, and leaves none to flow into the stream below. The spring is then said to be dry.

There are two conditions which may operate to start the spring flowing again. One is the falling of sufficient rain to replenish the reservoir so that it will be able to force out more water than can be at once evaporated, in which case some will flow away, and the occurrence will call for no public remarks. The second case is one that may happen with or without rainfall, and is caused by a lowering of atmospheric temperature with a consequent diminution of evaporation. When the outburst happens

in drought time, as the result of diminishing evaporation only, there is considerable comment, and the phenomenon is regarded by some casual thinkers as an indication that the drought will soon terminate, and by others that it will continue. The little rills which issue from the various springs and other moist places all unite, and cause a definite flow in the streams into which they drain, and this flow sometimes continues for very many miles.

Should an intermittent spring, fed by rainfall and without a storage reservoir, be situated a great distance from its source of supply, the water might take some months following an underground course to reach the outlet, in which case it is possible that the outbreak would occur during a dry period without being the result of diminished evaporation.

Evaporation.

The late H. C. Russell, F.R.S. carried out a considerable amount of investigation on the question of evaporation in New South Wales, and records an instance at Lake George in March, 1885, where in three days, while a northerly wind was blowing, the lake lost one and a half inches by evaporation.* Lake George is given as roughly 20 miles long and 5 miles wide.

Mr. Russell carried out various evaporation tests at Sydney during the year 1885. "Two dishes, each 8 inches deep and 2 feet on each side, that is, exposing 4 square feet of surface, were used for the purpose of testing the amount of water evaporated from soil, grass covered and bare . . . The evaporation from these dishes was tested by weighing once a day."* The daily mean in inches for the year was, grass covered 0.083, bare earth 0.071, water 0.100.

* This Journ. 1885, 19, 24.

* "Rain and River Observations made in New South Wales, 1885," by H. C. Russell, C.M.G. (Government Printer).

Mr. Russell wrote:—"The amount of evaporation depends very much upon the state of the soil; if it is wet on the surface the evaporation goes on from it much faster than from water; but as the ground dries the condition is reversed and the earth evaporates less than the water . . . The grass brings the subsoil water to the surface and aids evaporation in very dry weather, so that the evaporation from grassed soil is more regular than from bare soil, and in the course of the year it loses more than the dry earth by 20 per cent.; but in comparing it with water it evaporates 14 per cent. less."

The total evaporation for Sydney in 1885 is given as 36.514 inches, the monthly mean being 3.043. The lowest is given as 1.669 for July, and the highest as 4.683 inches for January.

The mean monthly evaporation at Bourke was 5.174 inches for the months April to December (inclusive), 1885, the lowest being 1.963 for July, and the highest 9.303 inches for December, the average evaporation per day being given as 0.169.

Atmospheric Effect on Flow from Springs at Kosciusko.

On the 16th and 17th February, 1920, two small swamps were noticed to be feeding tiny rills which were finding their way along the gutter on the roadside a short distance above the hotel, at an elevation of a little more than 5000 feet above sea-level. From sunrise until about 2.30 p.m. the sun shone full upon the road, but after this the springs and small streams came within the shadow of the mountain. The effect of diminishing evaporation was very clearly manifest on the flow of water as soon as it came within the shadow.

In the case of No. 1 stream, which was the more feeble of the two, it was found to extend 66 yards along the roadside from its source at 2.45 p.m., while at 5.45 p.m.

its length was 76 yards, but during the night, and at 7.30 a.m. the following morning it reached 92 yards from its source, and disappeared in the sand near a gully into which it doubtless found its way. During the whole of the following forenoon the length of the little rill was gradually shortened by evaporation, until again it reached only about 66 yards from its source.

No. 2 stream was fed from a little swamp about 50 feet by 20 feet, and extended 160 yards from its source at 2.30 p.m., while at 7.20 a.m. the following morning it reached 252 yards, or an additional 92 yards, and disappeared under a culvert. The evaporation from the heat of the sun operated on it so that by 10.5 a.m. it had receded 56 yards, and 88 yards by 12.25 p.m. and the volume in the little stream itself was much reduced.

Atmospheric Effect on Flow at Mittagong.

Water is impounded under large masses of basalt on the Mittagong Range, and finds its way out at various points where it forms swampy areas and springs. In May, 1923, a farm on the side of the range was visited, and it was found that the water for the stock was brought about 300 yards in a pipe one and a half inches in diameter from one of these springs which was open to the full rays of the sun. The farmer's statement was that during the summer months there was usually a full flow throughout the night and in the morning, but this would decrease towards the afternoon of a moderately hot day and perhaps cease at about 5 p.m., while on a very hot day the flow would cease altogether at about 2 p.m., though it would probably start again sometime during the evening. On one exceedingly hot day the water ceased and did not flow again until the following morning, when the weather was much cooler. This variation in flow clearly seems to be in response to variation in evaporation.

In June, 1923, it was found that the water from this spring had continued to run, day and night, since early in April, but as evidence that a spring without being replenished is not inexhaustible, the volume had become so reduced owing to continued dry weather that a one inch pipe was sufficient to carry off the water in June.

An Outburst at Bathurst in Dry Weather.

On the 25th February, 1923, a message was sent from Bathurst to the Sydney press as follows:—"What are regarded as signs of a continuance of the drought is the fact that in several portions of the Bathurst district springs have broken out and are running strongly. Vale Creek, which has been dry since last storm has now two inches of water running, as the result of the springs."

As it was thought that this outbreak of springs was consequent upon a fall of temperature having occurred some little time earlier, I recently obtained, through the kindness of Mr. E. W. Timcke, acting Meteorologist in charge of the Sydney Weather Bureau, the Bathurst temperature figures for the period in question, and they disclose a fall of 16 degrees from the 15th to the 16th February, 1923. When it is remembered that some days would elapse from the time the spring began to flow until it reached and was noticed some distance down the creek, it seems fair to assume that this particular outbreak was the result of a fall of temperature and a diminution of evaporation. How long this flow continued I am unable to say, but the returning heat probably soon terminated it.

It may be noted that on the 16th February, when the maximum temperature fell from 89 to 73 degrees, and the minimum fell as low as 47 degrees, the wind was from the east, and would contain more humidity and less evaporating properties than a wind coming to the Bathurst district from the west or north.

The temperatures in question are given below.

Bathurst February, 1923.	Minimum Degrees.	Maximum Degrees.	Wind 9 a.m.
12	50	88	calm clear
13	56	83	east light clear
14	55	90	east light clear
15	59	89	calm cloudy
16	55	73	east light overcast
17	47	86	calm few clouds
18	54	94	calm cloudy
19	57	95	calm clear
20	56	90	calm clear
21	54	98	east light clear
22	64	96	calm cloudy
23	57	101	calm fine
24	64	102	calm fine
25	67	98	calm fine

On the 17th April, 1923, a message was sent to the press from Bathurst stating that "Springs have broken out at the head of the Fish River, and a strong stream of clear water is now running into the Macquarie". An examination of the temperature figures at the Sydney Weather Bureau shows that the average maximum temperature at Bathurst from the first to the 17th April, 1923, was 72 degrees, but that on the 8th and 9th April the maximum was 64 and 65 degrees respectively. This fall in the temperature was probably responsible for the stream which a week later had reached the Macquarie.

There seems nothing remarkable in the fact that springs may start to flow on or after about the middle of April even in a drought period, for the rate of evaporation has considerably diminished by this time, and, even without any rain having fallen, it is not unusual to see a creek, which heads in a swamp, flowing more freely in May than in March.

It does not appear that the outbreak of springs in dry weather has any bearing on the duration of a drought.

DESCRIPTION OF THREE NEW SPECIES OF EUCALYPTUS AND ONE ACACIA.

By W. F. Blakely.
Assistant Botanist, National Herbarium, Sydney.

(With Plates XVII.-XX.)

(Read before the Royal Society of New South Wales, Oct. 3, 1928.)

Eucalyptus Joyceae, n.sp.

Arbor ad 20-60 pedes alta, nonnumquam duabus aut pluribus stirpibus a basi emergentibus; cortex asper, per pedes plures persistens, levis et deciduus in superiori trunco et in ramis; folia juvenilia pluribus parvibus opposita, orbicularia, elliptica vel late lanceolata, breviter petiolata, 4-5 x 2.5-4 cm.; folia adultiora alternata, petiolata, lanceolata vel obliquo-falcata, coriacea, frequentibus glandulis punctiformibus, 6-18 x 2-3 cm.; vernatio subconspicna, venae laterales ex angulo 30-40° surgentes a costa media; inflorescentia umbellis axillaribus 7-15 florum; gemmae clavatae, acutae, pedicellatae; calyx calathiformis circiter 3 mm. altus; operculum conicum vel fere rostratum; antherae reniformes; capsulae pyriformes vel fere pilulares, truncatae 5-7 x 6-8 mm.; ligum durum, fulvum vel badium.

A tree 20-60 feet high, sometimes Mallee-like, with two or more stems branching from the base, 1-2 feet in diameter. Barks persistent, light grey, coarsely flaky-fibrous for 6-12 feet, then smooth, deciduous, white or mottled on the remainder of the trunk and branches, and with the characteristic marking of *E. haemastoma* or *E. micrantha.*

Juvenile leaves rather thin, the first three or four alternate, succeeded by three or more pairs in the opposite stage, obicular, elliptical to broadly lanceolate, very shortly petiolate, 4-5 cm. long, 2.5-4 cm. broad; venation somewhat

fine, the numerous lateral veins much branched, especially in the orbicular leaves; intramarginal nerve distant from the edge.

Intermediate leaves broadly lanceolate to obliquely-lanceolate, acuminate, shortly petiolate, 7-13 cm. long, 4-8 cm. broad; venation moderately distinct on both surfaces, the lateral veins 18 to 23 on each side of the prominent midrib, somewhat irregular and diverging at an angle of 40-50° with the midrib; intramarginal vein distant from the slightly thickened revolute margin.

Adult leaves alternate, moderately thick, glossy, with numerous oil-dots, petiolate, lanceolate to obliquely-falcate-lanceolate, acuminate, 6-18 cm. long, 2-3 cm. broad; venation somewhat distinct, the lateral veins rather fine, making an angle of 30-40° to the midrib; intramarginal vein usually distant from the edge.

Inflorescence in axillary umbels or sub-paniculate owing to the suppression of the upper leaves; peduncles slightly compressed, somewhat slender, up to 2 cm. long. Buds clavate, acute, 7-15 in the head, distinctly pedicellate, the pedicels at first slightly angular, but as the fruit develops becoming rather slender and terete, 5-7 mm. long. Calyx somewhat goblet-shaped, about 3 mm. deep, 4 mm. across the top; operculum conical to almost rostrate, sometimes longer than the calyx-tube. Filaments white, all antheriferous. Anthers small, reniform, usually with a terminal gland.

Fruit pedicellate, pyriform to nearly pilular 5-7 x 6-8 mm. truncate, slightly contracted at the top. Disc usually forming a thin downward sloping reddish ring over the basal portion of the valves, but sometimes almost flush with the edge of the calycine ring; valves usually 4, invariably inclosed owing to the declivity of the capsular disc, which is most marked in some specimens.

Timber brown to reddish brown, darker than that of *E. piperita* and *E. Consideniana,* moderately hard and interlocked, with the characteristic gum veins of the above species. On the whole, it is harder and probably more durable than the timber of its congeners. For fuel purposes it is better than the timber of *E. piperita.*

Type from about one mile south of Kariong Trig Wondabyne, New South Wales (D. W. C. Shiress and W. F. B.).

The tree in the field conveys the impression of being intermediate between *E. haemastoma* and *E. piperita,* as it partakes of the cortical characters of both species, while the buds and fruits resemble those of the former, and the timber approaches more closely to that of the latter.

E. Joyceae is unique in that it connects the Peppermints with two Renantherous White Gums with red timber, namely, *E. haemastoma* and *E. micrantha,* which were tentatively placed in the Renantherae, apparently without any very close affinities, especially as regards the timber. But *E. Joyceae* appears to bridge the gap, not only in the colour of the timber, but also in other morphological characters, which, when carefully studied in conjunction with those of its allies seem to define more clearly its natural genetical relationship with the above-mentioned groups.

Named in memory of my adopted daughter Joyce, who, before her untimely death, assisted me in many little ways with my botanical work.

Range.

It appears to be confined to the Hawkesbury sandstone, between Parramatta and Gosford, singly or in small clumps, but, so far, I have not succeeded in finding its optimum. It is, however, more plentiful on the northern

side of the Hawkesbury River than on the southern side, and I predict that when it is better known its range will probably extend as far as Brisbane, Queensland.

The localities south of the Hawkesbury are—Parramatta, "Half-barked variety of White Gum" (Rev. Dr. W. W. Woolls). The fruits are broad and truncate, with a well-defined disc. Near the Suspension Bridge, North Sydney (D. W. C. Shiress). Stony Creek Road, about half-way between Pymble and De Burgh's Bridge (C. T. White and W.F.B.). When Mr. White's attention was drawn to the tree, he intimated that it resembled a tree growing around Brisbane. About one mile east of Wahroonga Railway Station, on the edge of the shale, where it grows into shaft-like trees, in association with *E. micrantha*, *E. Sieberiana*, *E. corymbosa*, and *E. resinifera* (W.F.B.); near the old Wool-wash, Spring Gully Creek, 1 mile east of Hornsby, and about ¼ mile north of Junction Road; also ½ mile west of the latter locality; between Collings Street and Junction Road (W.F.B.). On the track to Gibberygong Creek, Kuring-gai Chase, near the descent to the Bogey Hole (W.F.B.). Hill 60, about 1 mile north of Cowan; also on the east side of Cowan Tunnel, and on the top of the Tunnel (D. W. C. Shiress and W.F.B.); near the 26-mile post Cowan, twin trees 30 feet high, one foot in diameter. Bark rough at base for 6-10 feet, then smooth and blotched like the bark of *E. haemastoma*, for which it could easily be mistaken were it not for the rough, flaky bark at base, and the Peppermint-like odour of the leaves when crushed. The fruits are larger than the type, and about the same size as those of the co-type.

Localities North of the Hawkesbury.—Two trees found by D.W.C.S. and W.F.B. at the head of the long swamp, two miles north of Wondabyne; and two more on the rocks overlooking Mooney Mooney, about ½ mile north of

the first locality. There is also a large tree in an open gully, about ½ mile north of the second locality, and two more trees, one on each side of the Wallaby Rocks, ¼ mile east of the latter locality. All are small trees except one, with a little rough bark at base, and with the upper portion of the stems and branches smooth and white. About one mile south of Kariong Trig., on a rather exposed plateau about 700 feet above sea level, are nine trees, ranging from 40-60 feet high, and from 12 to 24 inches in diameter, all of which have rough bark at base and smooth bark on the branches. These may be regarded as the Type (D.W.C.S. and W.F.B.). On the Woy Woy-Gosford Road, about one mile from the junction of the new Wiseman's Ferry Road; also by the side of the new Sydney-Newcastle Road, about one mile below the junction of the former road.

A little below the junction of the old Wiseman's Ferry Road and the old road leading to the Industrial Home for Boys, Penang Range, near Gosford, are six trees ranging from 25 to 60 feet in height, and from 9-24 inches in diameter. They have the characteristic persistent rough bark at the base, smooth upper stems and branches as the Kariong trees. The largest, and probably the oldest, tree appears to be a very great age, and has indications of having weathered many storms and bush fires. In fact, nearly all the trees of *E. Joyceae* are severely charred and burnt to almost a shell at the base, and in some cases the original tree is burnt right out, and from the thin shell fresh shoots have sprung up and developed into lofty trees.

About 8 miles from Gosford, on the top of Penang Ranges. This specimen is recorded in error by J. H. Maiden in Proc. Linn. Soc., N.S.W., Vol. XXV., p. 109 (1900), as *E. stricta,* and as *E. Consideniana,* Maiden,

l.c., Vol. XXIX., p. 477 (1904), and is figured in error under *E. Consideniana* in the Critical Revision of the Genus Eucalyptus, Part X., Plate 46, figs. 9a, 9b, and referred to on page 314 as follows—Penang Mountain, Gosford (J.H.M. and J. L. Boorman), "Very like a Peppermint in appearance, only the bark is not so stringy —more flaky, white smooth limbs. A fair-sized tree and scarce (Andrew Murphy)." Co-type. At the bottom of page 315, Mr. Maiden, when discussing *E. Sieberiana* and *E. Consideniana*, again refers to it, i.e., "The Penang fruits are not perfectly typical; they show more than ordinary resemblance to *E. Sieberiana*." The fruits are not quite ripe, hence the very sharp rim which is due to the undeveloped state of the capsular disc.

Affinities.

1. With *E. haemastoma* Sm.

Trees of *E. Joyceae* could very easily be mistaken for *E. haemastoma*, as the cortical characters of the upper portion of the trunk and branches of both species are almost identical, except that the markings of *E. Joyceae* are less blotchy and greener, and are usually in broad irregular stripes, which is mainly due to the fact that the smooth bark decorticates annually in broad ribbons 2-10 feet long. While the bark of *E. haemastoma* sheds in small, broad flakes, rarely exceeding 12 inches long; it is also different in texture, being soft and brittle.

The juvenile leaves of both species are broad, but those of *E. haemastoma* are much broader and coarser than the leaves of *E. Joyceae;* while there is also an almost total absence of aromatic oil in the leaves of the former, it is always markedly present in leaves of the latter.

The adult leaves of both present the same general facies, but the leaves of *E. Joyceae* are, on the whole, smaller and less coriaceous than those of *E. haemastoma*, and, on

the other hand, they are furnished with more oil dots than the leaves of its ally.

The buds of *E. Joyceae* differ from those of *E. haemastoma* in being more acute or rostrate. As regards the fruits, they are somewhat similar in size and shape in both species, but the capsular disc of *E. Joyceae* is invariably more oblique, while the pedicels are frequently longer and more slender than those of *E. haemastoma.*

The timber of *E. Joyceae* is brown to reddish-brown, hard, and close grained; that of *E. haemastoma* is red, moderately soft and brittle.

2. With *E. piperita* Sm.

Some trees of *E. Joyceae,* especially those with the rough, persistent bark extending almost to the large branches would pass for this species. But an examination of the buds, fruits, juvenile leaves, and a closer scrutiny of the cortical characters of the latter will readily show that, although at first sight they appear to be alike, there is a marked difference between them when they are carefully investigated.

For instance, the persistent bark of *E. Joyceae* is more coarsely fibrous and of a yellowish-grey colour, while the smooth deciduous bark is whiter and sheds in longer and broader strips. The juvenile leaves are at least a size larger, more broadly lanceolate, and thicker than those of *E. piperita.* The buds of *E. Joyceae* are relatively larger, and the fruits also differ in shape, size and texture from those of its ally.

3. With *E. Bottii* Blakely.

The large fruits of this species somewhat resemble those of *E. Joyceae;* and there is also a general similarity in the juvenile and intermediate leaves. On the other hand,

E. Bottii grows to a much larger tree, and its persistent rough bark usually extends well out on the branches.

4. With *E. Consideniana* Maiden.

E. Joyceae is not unlike *E. Consideniana* as regards size and habit, but the persistent, rough bark of the former does not extend to the tips of the branches like that of the latter. The timber of *E. Joyceae* is darker and harder, while the buds are more acute, and the fruit is thinner and slightly different in shape. The juvenile leaves also differ from those of *E. Consideniana* in being less glaucous.

Description of Seedlings.

Hypocotyl slender, terete, purple-brown. Cotyledons reniform, somewhat unequally lobed, tapering into a long petiole,' 7 x 5 mm., dark green above, purple-brown beneath.

1st pair of leaves opposite, petiolate, oblong-lanceolate, 2 cm. long, 9 mm. broad, dark green above, purple-brown beneath; veins obscure. 2nd pair of leaves opposite, shortly petiolate, oblong, or nearly so, 4.5 x 2 cm., light green above, pale beneath. 3rd pair of leaves opposite, curved inward with shorter petioles than in the preceding pair, oblong-lanceolate, 7.5 x 2.3 cm.; venation obscure above, prominent beneath. 4th pair of leaves similar to the 3rd pair, but much longer with a broader base, 9.7 x 3.5 cm.; upper surface dark green, veins obscure; lower surface pale green; lateral veins conspicuous, diverging at an angle of 35-40° to the midrib; oil dots copious.

1st pair of alternate leaves lanceolate, petiolate, 12 x 3.8 cm.; venation and colour the same as the 4th pair. 2nd pair of alternate leaves lanceolate, petiolate, 13 x 4.3 cm.; upper surface dark green, veins distinct, midrib, lateral veins and margins a warm reddish-brown; lower

surface light green; veins prominent, green, diverging at an angle of 30-40° to the midrib; intramarginal vein 3-4 mm. from the margin.

Internodes terete, except at their junction with the leaves, purple-brown, ranging from 3-5 cm. long.

At 4 inches high *E. Joyceae* is almost identical with *E. anomala,* but after that, the leaves of the last-mentioned species become more sharply lanceolate and sessile, and they also continue in the opposite stage for a greater number of pairs than *E. Joyceae,* which does not appear to exceed four or five pairs at most.

The seedlings of *E. Joyceae* have fewer opposite leaves than those of *E. piperita;* they are, however, larger, and broader, also less glaucous and more lanceolate than those of the latter species.

Eucalyptus anomala n.sp.

Arbor 25-35 pedes alta; cortex pallide cinereus, rude diffissus et fibrosus, persistens inferiore trunco, at supra laevis candidusque; folia juvenilia opposita saltem decem paribus, late lanceolata, sessilia vel amplexicaulia; folia adultiora, petiolata, lanceolata vel obliquo-lanceolata, acuminata, crassa, coriacea, 5-19 x 2-3 cm.; venatio aliquantulum inconspicua, venae laterales tennissimae, divergentes angulo 35-40° a costa media; umbellae axillares vel pseudo-paniculatae; gemmae 10-20 in umbella, pedicellatae, clavatae, fere omnino obtusae; tubus calycis subcalathiformis, 4-5 mm. diametro; operculum scutellariforme, apiculatum; antherae omnes fertiles, parvae, reniformes; capsulae subpyriformes, pedicellatae 7-8 v 6-8 mm.; lignum pallidum, fissile.

Trees 25-30 feet high, 9-12 inches in diameter, with a rough coarsely fibrous light-grey bark on the lower portion of the trunk, the upper portion smooth and white, which decorticates annually in long narrow ribbons.

Juvenile leaves opposite for six or more pairs, cordate-lanceolate to lanceolate, sessile to somewhat amplexical. 8-16 x 3-7 cm.

Adult leaves alternate, petiolate, lanceolate to obliquely-lanceolate, acuminate, thick, coriaceous, 5-19 x 2-3 cm. Venation somewhat obscure; lateral veins very fine, diverging at an angle of 35-40° to the midrib; intramarginal vein usually distant from the margin.

Inflorescence in axillary umbels or forming moderately large pseudo-panicles owing to the suppression of the upper leaves, as is often seen in *E. haemastoma* and *E. umbra.* Peduncles compressed, dilated and thickened at the top, 10-20 mm. long. Buds 10-20 in the umbel, pedicellate, clavate, almost obtuse; pedicels slightly angular, up to 7 mm. long. Calyx somewhat goblet-shaped, about 3 mm. deep, 4-5 mm. broad. Operculum shorter than the calyx-tube, apiculate, scutelliform, with a minute internal appendage suspended from the top. Filaments numerous, white, except at the extreme base, which are a pale purple, all antheriferous. Anthers small, reniform, the broad papery cells usually tipped with a minute globular gland.

Fruit pedicellate, shortly pyriform, 7-8 x 6-8 mm., truncate or more or less slightly domed; disc reddish, moderately broad, forming a slightly thickened ring around the base of the valves, and extending almost over the tips in a very thin layer; valves usually four, enclosed; pedicels conspicuous, slightly compressed and wrinkled, 5-9 mm. long.

Timber pale, close-grained, fairly light, slightly darker than that of *E. umbra* when fresh but apparently of the same texture.

It is an interesting species from a taxonomic standpoint, as it appears to form a natural connecting link between the Stringybarks, and the Gums belonging to the Renantherae section.

The field and botanical characters of *E. anomala* so closely resemble those of *E. Joyceae* that Mr. Shiress and myself for some time failed to distinguish the difference between them, except that the venation of the leaves of *E. anomala* was somewhat finer, and the leaves possessed a slightly different perfume to those of *E. Joyceae*. Seeds of both species were sown to ascertain whether there would be any marked difference between the young plants. When the seedlings had reached a height of five inches, the leaves of those of *E. anomala* were found to be totally different from those of *E. Joyceae,* both as regards size and shape, and in being opposite for a greater number of pairs. They also showed a marked affinity with those of *E. umbra* and *E. acmenioides,* two members of the Stringy-bark series, while the seedlings of *E. Joyceae* displayed a striking resemblance to *E. piperita* on the one hand, and *E. haemastoma* on the other, and may be described as being intermediate in character between the two species.

Range.

So far it is known from Bywater, near Brooklyn, Hawkesbury River, where it grows in association with *E. umbra*, *E. haemastoma* and *E. punctata;* on the southern side of Sugarloaf, about five miles north of Brooklyn; also about one mile due east of Cowan Railway Station, New South Wales (D.W.C. Shiress and W.F.B.).

Affinities.

A close examination of the botanical characters and its appearance in the field seem to suggest that it is a natural hybrid between *E. haemastoma* and *E. umbra*, and it may be described as a rough-barked *haemastoma,* or a partly smooth-barked *umbra*.

The persistent rough-bark is very different both in general appearance and in texture from that of *E. umbra*. While the smooth bark, although deciduous at one period

of the year, is unlike the bark of *E. haemastoma* in that it exuviates in long, narrow ribbons, and not in short, broad pieces like the last named species. The venation of the leaves is intermediate between that of *E. haemastoma* and *E. umbra;* while the buds and the fruits resemble those of the former species. The juvenile leaves, however, are of the *E. umbra* type, and, therefore, sharply separate it from *E. haemastoma,* placing it without doubt in the Stringybark series, notwithstanding the difference in the texture of the bark, and other morphological distinctions.

Description of Seedlings.

Hypocotyl slender, terete, purple-brown.

Cotyledons oblong-reniform, almost uniform without any depression in the centre as is the case with many cotyledons belonging to the Reniformae Section, 8 x 5 mm., trinerved, dark green above, purple-brown beneath.

1st pair of leaves opposite, petiolate, narrow-lanceolate to acute, 2.5 x 1 cm., dark green and obscurely veined above, purple-brown beneath. 2nd to 6th pair of leaves opposite, lanceolate to cordate-lanceolate, sessile to amplexical, 9-14 x 3-6 cm., dark green above, pale green beneath; veins moderately fine, the intramarginal vein slightly remote from the edge. Internodes elongated, terete, except the broadly dilated portion close to the leaves, reddish to a deep purple-brown.

In all stages up to 4 inches they are almost inseparable from those of *E. Joyceae;* after that they resemble the seedlings of *E. umbra* and *E. acmenioides.*

EUCALYPTUS WARDII, n.sp.

Arbor erecta, Stringybark, 60-70 pedes alta, 1-2 pedes diametro; cortex crassus, fibrosus, ad parvos ramos persistens; folia juvenilia 2-3 paribus opposita, angusto-lanceolata, breviter petiolata, 3-12 x 1-2 cm., pallide viridia, glabra, nitentia; folia

adultiora alternata, petiolata, lanceolata vel falcato-lanceolata, acuminata, 8-20 x 2-4 cm., obscuro-viridia; venae laterales a costa mediana angulo 45° diver gentes; inflorescentia umbellis exillaribus 7-14 mediocrium alborum florum; gemmae pedicellatae, fasciculis stellatim radiantibus, pedunculo subtereti 10-14 mm. longo; calyx cyathiformis, 4 x 3 mm.; operculum plerumque rostratum, 4-5 mm. longum; anterae reniformes; capsulae ovales vel pyriformes, pedicellatae, 8 x 8 — 9 x 10 mm. solidae, parvum aditum praebentes; discus bene finitus, ex parte supra valvas capsulae profunde inclusas extendens.

An erect Stringybark, 60-70 feet high, 1-2 feet in diameter; bark thick, furrowed, fibrous, persistent to the small branches, branchlets sub-terete.

Juvenile leaves (not seen from the base of the tree but from the fruiting branches only) opposite for the first two pairs, narrow-lanceolate, falcate-lanceolate to acuminate, shortly petiolate, 3-12 x 1-2 cm., light green, smooth and shining without the slightest trace of stellate hairs.

Intermediate leaves (not seen from young saplings, but from branch suckers only) alternate, narrow lanceolate or obtuse-lanceolate, shortly petiolate, slightly oblique, 9-10 x 3-4.5 cm., light green with a somewhat obscure venation.

Adult leaves alternate, petiolate, lanceolate to falcate-lanceolate, acuminate, slightly oblique, 8-20 x 2-4 cm., dark green and glossy on both surfaces, moderately thick. Venation somewhat obscure, the very fine lateral veins diverging at an angle of 40-50° to the midrib; intramarginal nerve distant from the margin. Oil dots small, copious.

Inflorescence in axillary umbels of 7-14 white flowers. Buds pedicellate, subfusiform, light green, radiating in stellate-like clusters on sub-terete peduncles 10-14 mm. long. Calyx wine-glass shaped, 4 x 3 mm. Operculum acuminate to rostrate 4-5 mm. long. Filaments white, flexuose, nearly all fertile; anthers reniform, usually crowned with a large globular gland.

Fruit oval to pyriform, distinctly pedicellate, 8 x 8 - 9 x 10 mm. thick, contracted at the top into a small orifice; disc forming a well-defined ring inside the calycine border, and which extends partly over the small, somewhat deeply enclosed valves of the capsule. Timber pale, very fissile.

Range.

Confined to the Port Jackson district so far as we know at present.

Gladesville (J. L. Boorman); Lane Cove River near Killara (J. H. Maiden, Dec. 1898). The late Mr. Maiden suggested that it might be a natural hybrid between *E. pilularis* and *E. eugenioides*. Near the old Wool-wash, Spring Gully Creek, Hornsby (Ray Fogarty, E. Stanton and W.F.B., June 1928). The type. On the Galston Road 1¼ miles from Hornsby (D. W. C. Shiress and W.F.B., July 1916). One mile S.W. of Parramatta (R. H. Cambage, March, 1901, B.).

Named in honour of my esteemed friend and colleague, Mr. E. N. Ward, Curator, Botanic Gardens, Sydney.

Affinities.

1. With *E. nigra* R. T. Baker. Both species are somewhat alike in carpological characters, but the fruits of *E. nigra* are much thinner than those of *E. Wardii;* the buds of the former are also smaller and less rostrate, while the juvenile leaves are narrower; and there is a marked difference in the perfume of both species.

2. With *E. eugenioides* Sieber. It is readily distinguished from this species by the large subpyriform fruits, and in the more rostrate buds.

3. With *E. Muelleriana* Howitt. The fruits of *E. Wardii* resemble those of its ally both as regards shape and sculpture, but on the whole they are smaller, while the buds are totally different, being rostrate and not clavate like the buds of *E. Muelleriana*.

UNINERVES (RACEMOSAE).

ACACIA LUCASII, n.sp.

Frutex humilis ramis cinero-tomentosis, germinibus juvenilibus dense cinereo-ferrugineis; phyllodia uninervia, ovata vel elliptico-lanceolata, undulata, breviter petiolata, subrigida, hirsuta, scabra, marginibus nervum flavescentem simulantibus, 2.5-3 cm. longa, 9-18 mm. lata; inflorescentia praebens capita pedunculata vel racemos supra phyllodia prominentes; capita dense villosa 12-20 flores comprehendunt; calyx parvus, sinuose lobatus, hirsutus, duplo brevior corollae attenuatae; petala 5 ex parte conjuncta, angusto-lanceolata, hirsuta, solida, incurva; legumina breviter stipitata, dense ferrugineo-tomentosa, oblonga, obtusa, 2-4 cm. longa, 1 cm. lata; semina breviter obliqua; funiculus filiformis, in arillum candidum navicularem desineris.

A small shrub, branches hoary-tomentose, the young shoots and pods densely hoary-ferrugineous, phyllodia uninerved, ovate to elliptical-lanceolate, undulate, shortly petiolate, somewhat rigid and more or less hirsute and scabrous, the yellowish nerve-like margins conspicuous, and furnished with a small basal gland, 2.5-3 cm. long, 9-18 mm. broad. Stipules small, black-pointed, semi-rigid, moderately persistent and partly hirsute.

Inflorescence in pedunculate heads or more frequently in flexuose, pubescent racemes exceeding the phyllodia. (Perfect flower-heads not seen.) Heads globular, densely villose, of 12-20 moderately large flowers.

Calyx small, sinuately lobed, hirsute, scarcely half the length of the attenuated corolla. Petals 5, united near the centre, hirsute, narrow-lanceolate, thick, incurved. Ovary densely tomentose. Bracts spathulate to diamond-shaped, concave at the back, with glandular, hirsute hairs concealing the calyx.

Pods shortly stipitate, densely ferrugineous-villose, oblong, obtuse, with thickened nerve-like margins, 2-4 cm. x 1 cm. or larger. Seeds slightly oblique, jet black, ovate.

Funicle filiform for about half its length, finally terminating in a white, navicular arillus nearly the length of the seed.

Named in honour of my friend and colleague, Mr. A. H. S. Lucas.

Range.

Bumbury Creek and Green Hill, 3 miles towards Wadbilliga, Tuross River district, New South Wales (Miss M. A. Harnett, 16th January, 1928).

Near *A. podalyriaefolia* in the phyllodia, but totally distinct from it in the 5-merous flowers, densely ferrugineous-tomentose or villose young shoots and pods. The pods are remarkable for their rich vestiture, which is a striking contrast against the light green phyllodia with their yellowish margins, and thereby *A. Lucasii* is readily distinguished from all the Eastern species.

ACACIA KYBEANENSIS Maiden and Blakely; this Journal 1927, 60, 188.

Pods not previously described.

Pods oblong, moderately straight, distinctly stipitate, apiculate, glabrous, slightly glaucous, the valves thin, scarcely coriaceous, 3.5-5.5 cm. long, 1.5 cm. broad. Seeds oblique or nearly so, ovate, jet black; funicle white, filiform for about half its length, then thickened into a carnose navicular aril nearly the length of the seed.

The broad pods connect it with *A. podalyriaefolia.*

Tuross River (Miss M. A. Harnett, December, 1927).

I wish to express my thanks to Dr. G. P. Darnell-Smith, Director, Botanic Gardens, Sydney, for his advice and interest in this paper.

E. Joyceæ Blakely.

E. anomala Blakely.

E. Wardii Blakely.

Acacia Lucasii Blakely.

EXPLANATION OF PLATES.

Plate XVII.

Eucalyptus Joyceae Blakely.

1. A large juvenile leaf.
2. Buds and fruits, all from one mile S. of Kariong Trig. The type.
3. Fruiting branch, 8 miles from Gosford on the top of Penang Ranges (Andrew Murphy). Co-type.

Plate XVIII.

Eucalyptus anomala Blakely.

1. Young buds; 1a, fully developed buds and flowers.
2. Fruiting branch.
3. Juvenile leaf. All from Bywater.

Plate XIX.

Eucalyptus Wardii Blakely.

1. Portion of a fruiting branch producing a sucker with two pairs of opposite leaves.
2. Buds.
3. Fruits. All from the same tree, Spring Gully Creek, Hornsby.

Plate XX.

Acacia Lucasii Blakely.

Portion of a branch showing phyllodia and pods.

"THE CHEMISTRY OF THE EXUDATION FROM THE WOOD OF *PENTASPODON MOTLEYI.*"

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and
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(Read before the Royal Society of New South Wales, 5th Dec., 1928.)

Mr. C. E. Lane-Poole, Inspector-General of Forests, Australian Forestry School, Canberra, in a communication dated 28th November, 1927, enquired if the Sydney Technological Museum would undertake the examination, with special reference to its economic utilisation, of a certain oil which exudes from a tree occurring in New Guinea, and identified as close to *Pentaspodon Motleyi.* In compliance with this request, the examination was readily undertaken, and a quantity of the oil, which previously was obtainable in very limited quantity and difficult to procure, was made available. As a matter of fact, Mr. Lane-Poole reports that the quantity supplied, about 2 pints, took him four years to obtain.

The botanical description and general characters of the tree yielding this remarkable exudation are given in Mr. Lane-Poole's Report, "The Forest Resources of the Territories of Papua and New Guinea," 1925, page 109. (This publication is printed and published for sale by the Commonwealth Government of Australia).

The following interesting and necessary particulars which furnish an account of the physical characters and source of the exudation are extracted therefrom, viz.:—

"The wood of this large tree, 8 feet girth, bole 80 feet, 120 feet over all, contains an oil in such abundance that it may be collected in conveniently placed receptacles, much as resin is collected from the Maritime Pine, only the cut must reach the heart. In many cases the flow is very heavy, and in one instance a gallon of oil was collected in three hours. In such cases it is probable that reservoirs of oil have been formed in hollows caused by rot, and the axe has tapped a crack that has piped off the supply. While a microscope may yield some explanation of the formation of the oil in the wood, a lens shows no special canals or vessels as one would expect to see. The oil is heavy and misty brown in colour; it resembles motor lubrication oil as used for cylinders. It has a smell which is hard to describe, though somewhat familiar—somewhat fishy linseed oil is the nearest I can get to it."

We can confirm the physical characters so aptly described by Mr. Lane-Poole. To all intents and purposes, the oil, on account of its dark brown colour, viscosity, odour, etc., might easily be mistaken for a commercial boiled linseed oil.

Referring again to the origin of the exudation, Mr. Lane-Poole, in a private communication, states:—

"Microscopic examination shows that the medullary rays have canals, and these, even from dried specimens of the wood, still store their quantity of oil. This is clearly visible with the liberkuhn method of illumination. I am sending you a sample of the wood, so that you may examine it, also you will see that the oil exudations are visible to the naked eye."

Mr. M. B. Welch, B.Sc., A.I.C., Economic Botanist at the Sydney Technological Museum, who examined the small sample of wood referred to above, furnished the following report thereon, viz.:—

"The wood has been examined microscopically, and Sudan III. and alkannin both show the presence of oily bodies in the cavities of the sparsely distributed medullary secretary passages, in the cells of the thick walled protective sheath surrounding the canal, and to a slight extent in some of the wood parenchyma adjoining the canal, but nowhere else. The canals observed varied from 18-55 $\mu\mu$ in diameter. The con-contents were practically all soluble in 95% alcohol."

The very small original sample of exudation secured by Mr. Lane-Poole was submitted to Mr. T. G. H. Jones, University of Queensland, Brisbane, and his report is pub-

lished in the "Forest Resources of Papua and New Guinea," 1925, pages 168-169. Unfortunately, the quantity available did not enable this chemist to make more than a preliminary examination, and beyond the statement that it consisted of unsaturated acids possessing a molecular weight of about 400, no other data has been published.

The present investigation of the larger samples submitted has shown the exudation to consist approximately of about 90-95% of acid bodies possessing unusual characters. The crude oil is non-volatile in steam, and we were unable to effect its distillation under reduced pressure (1 mm.) without decomposition. Consequently, it is very difficult to produce evidence as to whether the principal component is a chemical entity or a mixture. For the purpose of this announcement it is regarded as a single acid. Evidence is adduced under "Experimental" which shows the principal acid to be mono-carboxylic with two hydroxyl groups, and to possess the molecular formula $C_{24}H_{36}O_4$. It gives a beautiful violet colouration with ferric chloride in alcoholic solution. Unfortunately, no crystalline or solid derivatives (except the silver salt) could be prepared.

The original objective of the investigation was to ascertain if the oil possessed any economic value. Consisting essentially of an acid or acids of high molecular weight, it yielded soaps with alkalies, which technically possessed special merits on account of their valuable emulsifying properties. At present, no other commercial use can be suggested. Its economic utilisation depends entirely on the possibility of supplies being obtained in commercial quantities. At present the prospects of its availability in large quantities at a cost which would enable it to compete with rosin or similar products is not promising, judging from Mr. Lane-Poole's report. However, very little is known of the extent of the natural products of New Guinea in its present undeveloped condition.

Experimental.

The two samples of oily exudation received gave the following chemical and physical constants on examination:

	Sample No. 1.	Sample No. 2.
Specific Gravity, ..	1.011	1.01
Refractive Index, 20° C ..	1.5280	1.5295
Acid Number	139.08	138.24
Saponification Number ..	142.09	146.64
Solubility in 70% Alcohol (by weight)	2.6 vols.	2.5 vols.
Acid Number after acetylation	102.07	102.53
Iodine Number (Wijs) ..	——	192.1
Reaction with Ferric Chloride in ethyl alcohol solution	Deep violet colour with precipitate forming on standing.	

It was found early in the investigation that the crude oil was soluble in 8% aqueous sodium hydroxide solution, and, therefore, in order to determine if the constituents were of a variable nature it was treated with 1% aqueous solution ammonium carbonate, 5% aqueous sodium carbonate, and 8% aqueous sodium hydroxide solutions respectively. The best procedure was to dissolve the crude oil in approximately four times its volume of ether, and to treat repeatedly with the reagents mentioned.

Ammonium Carbonate Extract.—On acidification with dilute sulphuric acid, extraction with ether and removal of solvent, only 0.8% of a dark brown viscous residue was obtained. It gave a faint violet colouration with ferric chloride in alcoholic solution much resembling the crude oil and main component, and was found to possess an acid number of 114.2.

Sodium Carbonate Extract.—Shaking at room temperature with this reagent failed to remove more than a trace of acid bodies.

Sodium Hydroxide Extract.—On treatment with this reagent the greater part of the oil went into solution. On acidification with dilute sulphuric acid, extraction with ether, and removal of solvent, 93% of a dark reddish brown viscous oil, much resembling the crude exudation, was recovered.

Neutral Residue.—The main ethereal solution on removal of solvent yielded 5% of a yellow viscous oil with an acid number of 11 and refractive index of 1.5330. It did not give a colour reaction with ferric chloride in alcoholic solution.

Examination of Principal Acid Constituent.

Soluble in 8% sodium hydroxide solution.

This component, which constituted over 90% of the crude exudation, was found to possess the following chemical and physical characters, viz.:—

Specific Gravity, ...	1.0132
Refractive Index, 20° C	1.5270
Solubility in 70% alcohol (by weight)	3.3 vols.
Acid Number	145.52
Do. after acetylation	106.5
Saponification No.	152.90
Do. after acetylation	203.24
Iodine Number (Wijs)	188.3
Molecular weight for monobasic acid calculated from Acid Number	385.

Colour Reaction.—A very striking violet colour reaction was obtained when a drop of ferric chloride solution was added to a dilute alcoholic solution of this acid. A similar coloured precipitate separated on standing.

Molecular Formula.—The following results were obtained on combustion, viz.:—

(1) 0.1068 gram gave 0.2902 gram CO_2 & 0.0919 gram H_2O

$C = 74.1\%$. $H = 9.56\%$.

(2) 0.1040 gram gave 0.2824 gram CO_2 & 0.0884 gram H_2O

$C = 74.0\%$. $H = 9.44\%$.

(3) 0.1154 gram gave 0.5136 gram CO_2 & 0.0970 gram H_2O

$C = 74.6\%$. $H = 9.34\%$.

$C_{24}H_{36}O_4$ requires $C = 74.23\%$. $H = 9.23\%$.

Molecular Weight Determination.—A molecular weight determination by the Landsberger boiling point method, using acetone as solvent, gave the following result, viz. :—

1.5416 grams in 21 c.c. acetone elevated the boiling point 0.42° (average of 8 readings). M.Wt. = 384

$C_{24}H_{36}O_4$ required M.Wt. = 388

Silver Salt.—The silver salt was prepared by neutralisation of the acid body with dilute ammonia solution and precipitation with silver nitrate solution. 0.7658 gram silver salt gave on ignition 0.1650 gram silver = 21.55% silver. The silver salt of $C_{24}H_{36}O_4$ requires 21.82% silver.

Copper Salt.—On trituration of the acid with excess of copper carbonate no action appeared to take place at room temperature, but upon heating at water bath temperature a vigorous reaction resulted. The green copper salt was extracted by means of acetone, and was found upon removal of the solvent to be a very viscous and sticky green paste which would not solidify.

0.5722 gram of copper salt gave 0.0544 gram CuO on ignition = 9.51% CuO.

The copper salt of a monobasic acid of molecular formula, $C_{24}H_{36}O_4$ would yield by calculation 9.44% CuO.

Presence of "CO" and "OH" Groups.

The presence of "carbonyl" groups could not be detected by the use of hydroxylamine or semi-carbazone salts. The solubility, colour reaction, and general chemical deportment, so far observed, point to the presence of one

"carboxyl" group and two "hydroxyl" groups in the molecule of this acid. The presence of the latter was demonstrated by the reactions with phenylisocyanate and particularly with napthylisocyanate, but no definite crystalline derivatives could be isolated from the reaction mixtures.

Action of Bromine.—Treatment with bromine at —20° in both dry ether and carbon disulphide solutions respectively yielded sticky masses which could not be induced to crystallise.

THE ESSENTIAL OIL FROM A BORONIA IN THE *PINNATÆ* SECTION.

FROM FRAZER ISLAND, QUEENSLAND.

(Together with a resumé of the essential oils from other closely allied pinnate leaf Boronias.)

By A. R. PENFOLD, F.A.C.I., F.C.S.
Curator and Economic Chemist, Technological Museum, Sydney.

(Read before the Royal Society of New South Wales, 5th Dec., 1928.)

Shortly after the publication of a joint paper with Mr. M. B. Welch, B.Sc., A.I.C., Economic Botanist, Technological Museum, Sydney, on the Botany and Chemistry of *Boronia pinnata* (Smith) and *Boronia thujona* (sp. nov.) (This Journal, Vol. LV. (1921), pages 196-209), material from a pinnate leaf Boronia from Frazer Island, Queensland, was kindly furnished by Mr. C. T. White, F.L.S., Government Botanist of that State. It has been known up to the present as the "Thin-leafed" *Boronia pinnata* from Frazer Island.

The examination of the essential oil from but a pound weight of the leaves and terminal branchlets revealed a striking difference between it and the oils from closely allied species. Supplies of the leaves and terminal branchlets in quantity were accordingly procured through the good offices of the Queensland Forest Service for the express purpose of examining the essential oil. The leaves, on crushing between the fingers, emitted the powerful and characteristic odour of safrol. Mr. C. T. White, F.L.S., Government Botanist of Queensland, and Mr. E. Cheel, Curator of the National Herbarium, Sydney, have given much attention to the study of this thin-leafed form of

Boronia pinnata, and both are of the opinion that it is probably a form of either *Boronia thujona* (Penfold and Welch) or of *Boronia Muelleri* (Cheel). It is necessary at this stage briefly to review the scattered data on the characters and chemistry of these closely allied species of Boronia in order that the points of difference between those already described and this new form may be clearly demonstrated.

In the first instance, a paper entitled "On the Essential Oil of *Boronia pinnata,* Sm., and the presence of Elemicin," by H. G. Smith, F.C.S., was published in the "Proceedings of the Royal Society of Victoria," Vol. XXXII. (new series), part 1, 1919, pages 14-19. The species of Boronia referred to therein as *B. pinnata,* Sm., was later shown by Mr. E. Cheel to be identical with *B. pinnata* var. Muelleri, Bentham. This worker considered it to be worthy of specific rank and accordingly named it *Boronia Muelleri,* sp. nov. (See this Journal, Vol. LVIII. (1924), page 147). Leaves and terminal branchlets were kindly furnished in 1925 by Miss C. C. Currie, of Lardner, Victoria, through the Forestry Commission of Victoria, and the results obtained in the examination of the essential oil confirmed those obtained by the late H. G. Smith in the paper referred to above. (See under "Experimental.")

Although Mr. E. Cheel finds difficulty in separating this species, *B. Muelleri,* from *B. thujona* by any well-defined botanical characters (see paper, "Notes on Boronia in the pinnatæ section, with a description of a new species," by E. Cheel, this Journal, Vol. LVIII. (1924), page 148), the writer, who has handled the material in bulk for oil distillation, has been able to discern a marked difference in general appearance, both in disposition of foliage and flowers. As a matter of fact, it is the most abundant flowering pinnate leaf Boronia I have as yet observed, the long terminals being especially heavily laden with blossom.

Referring now to the thin-leafed Boronia from Frazer Island, the Queensland Forest Service, in a letter under date 25th August, 1927, furnished the following particulars regarding its habitat which were supplied by the officer responsible for the collection of the material forwarded for oil distillation purposes.

> "On Fraser Island *Boronia pinnata* occurs in moist gullies and on the edges of fresh water swamps and creeks, where plenty of moisture is obtainable, but where the sun has play upon its foliage. The soil is composed of sand and rotting humus. It there grows in association with *Leptospermum Liversidgei, Banksia latifolia* and grasses and shrubs found in this type of country. The associated trees are Broadleafed Tea tree (*Melaleuca leucadendron*) and Swamp Mahogany (*Eucalyptus robusta*). The Boronia varies in height from two to six feet with a maximum stem diameter of one inch at ground level."

The habitat of *Boronia thujona* is very similar, but it has been observed to attain a greater height, sometimes up to 12 feet from the ground, with a stem diameter of 2ins. at ground level. The writer suggests that the Frazer Island Boronia be considered as a form of *B. thujona* until such time as botanical science is able to bring forward morphological or other evidence that will differentiate it from the closely allied species or forms.

Although the essential oil is particularly high in content of safrol it is a species quite distinct from *Boronia safrolifera*, which is easily determinable by botanists (see this Journal, Vol. LVIII, 1924, page 146 and pages 230-233, papers by Cheel and Penfold, respectively).

The essential oils of the various species in the pinnatæ section show a remarkable diversity in chemical composition, particulars of which are given in the summary at the end of this paper.

The Essential Oils.

Pinnate Leaf Boronia from Frazer Island, Q.
(B. thujona, var. "A.")

Two hundred and twenty-two and a half pounds weight of leaves and terminal branchlets were kindly furnished through the courtesy of the Queensland Forest Service. On distillation with steam, yellow oils, heavier than water, highly refracting and fluorescent, and smelling strongly of safrol, were obtained in a yield of 0.5 to 0.6% (second consignment ignored on account of loss of oil during drying and transit). The chemical and physical characters are shown in table I.

The principal constituents, so far identified, were found to be safrol (75-80%) and *l*-limonene, with small quantities of phenolic bodies, sesquiterpene, and a paraffin of M.Pt. 65-66°.

Experimental.

The two principal distillates gave the following results on distillation, viz.:—

17/9/1923. 80 c.c., after removal of 0.61 gram phenolic constituents, commenced to distil at 70° (20 mm.), 20% distilled below 107° (10 mm.), and 75% distilled between 108°-112° (10 mm.).

24/7/1925. 100 c.c. crude oil after removal of 0.1 gram phenolic constituent yielded 11% between 70° (20 mm.) and 107° (10 mm.), 4% between 70°-106° (10 mm.), 80% between 106°-112° (10 mm.).

Determination of Limonene.—The lower boiling fractions of the above distillates were subjected to repeated fractional distillation over metallic sodium with the following results:—

TABLE I—*BORONIA THUJONA*, VAR. "A," from Frazer Island, Queensland.

Date.	Weight of Leaves.	Yield of Oil.	$d\frac{15°}{15}$	$\alpha^{20°}_{D}$	$n^{20°}_{D}$	Solubility in 80% Alcohol, (by weight.)	Ester No. 1½hrs. hot sap.	Ester No. after Acetylation.	Remarks.
17/9/1923	70lbs.	0.53%	1.0565	−11.2°	1.5255	5½ vols. with separation of Paraffin)	10·8	20.5	
15/1/1925	82½lbs.	0.07%	1.0189	−11°	1.5154	6 vols.	9.4	28.6	Leaves very dry and partially decomposed. Oil lost probably during drying and in transit, hence abnormally low yield.
24/7/1925	70lbs.	0.62%	1.0563	−8.6°	1.5260	9 vols.	6.3	22.1	Leaves carefully air dried in shade prior to packing for despatch to Sydney. Weighed 90lbs. when collected; yield of oil on this weight = 0.5%.

17/9/23 Lot. Boiling Point, 66° - 72° (10mm); $d\frac{15°}{15}$, 0.852; $\alpha_D^{20°}$, -78.75°; $n_D^{20°}$, 1.4751°.

24/7/25 Lot, Boiling Point, 174° - 177°(767mm); $d\frac{15°}{15}$, 0.8512; $\alpha_D^{20°}$, -45°; $n_D^{20°}$, 1.4718.

Both fractions, after being saturated with water, and dissolved in four times their volume of glacial acetic acid, were treated with bromine at —20°. On standing overnight in the ice chest, characteristic crystals of limonene tetrabromide separated, which, on isolation, drying and recrystallisation from ethyl acetate, melted sharply at 104°.

Determination of Safrol.—The fractions distilling between 106°-112° were placed in a bath of solid carbon dioxide, and the frozen mass transferred to a Buchner filter funnel surrounded with a mixture of ice and salt. The crude safrol thus obtained was further purified by redistillation. It gave the following constants on examination, viz.:—

B.pt. 109° - 110° (10mm); Melting point +11°, $d\frac{15°}{15}$, 1.1045; $\alpha_D^{20°}$, ±0°; $n_D^{20°}$, 1.5382.

The filtrate from the solid safrol was found to be free from methyl eugenol, and to consist mainly of safrol with a little sesquiterpene.

The identity of this phenol ether was confirmed by boiling on a sand tray, for a prolonged period, 30 c.c. of the purified safrol in 200 c.c. of ethyl alcohol containing 8 grams of sodium in solution. The iso-safrol obtained gave the following results on examination, viz:—

B.pt. 120½° - 122° (10mm); $d\frac{15°}{15}$, 1.123; $n_D^{20°}$, 1.5740

On oxidation with chromic acid in glacial acetic acid solution solid heliotropine was obtained, which, on purification through the bisulphite compound, melted sharply at 37°.

Determination of Minor Constituents.—The residues from the distillation of the Safrol fractions were found to contain small quantities of sesquiterpenes, just detectable by the well-known colour reactions with bromine in acetic acid solution and sulphuric acid in acetic anhydride solution.

Phenolic Bodies.—The first consignment examined yielded 0.6 gram crude liquid phenol removed from 80 c.c. oil by means of 8% sodium hydroxide solution. It possessed a refractive index of 1.5130 and gave a brilliant orange red colouration with ferric chloride in alcoholic solution, and formed an ammonium salt melting at 132°-133°. It bore a close resemblance to the remarkable constituent isolated from the oil of *Backhousia angustifolia* by means of 8% sodium hydroxide solution and tentatively termed a "phenol" (see this Journal, Vol. LVII, 1923, pages 300-312).

The last consignment, 24/7/'25, yielded only 0.1% crude liquid phenol, giving an indifferent colour reaction with ferric chloride in alcoholic solution, and apparently was in no way related to that isolated from the first distillate.

Paraffin.—The residues from the distillation of the fractions rich in safrol were found to contain small quantities of paraffin, which, on purification from alcohol, melted at 65-66°.

Boronia pinnata (Smith).

Previous attempts to determine the identity of the principal terpene were unsuccessful (see this Journal, Vol. LV. (1921), pages 199-200), but recently a small yield of limonene tetrabromide of melting point 104° was obtained from the terpene fraction. This offers confirmation of the identity of the principal terpene with limonene, which body was thought to be present, though no evidence in support could be secured.

Boronia thujona (Penfold & Welch).

Further supplies of the leaves and terminal branchlets from numerous localities have been examined since the publication of this species (see this Journal, Vol. LV. (1921), pages 200-208), and the results obtained have in every instance confirmed those originally published. A consignment of leaves from Pymble, N.S.W., gave the highest yield obtained to date with fresh material, viz., 0.8%. The author had the pleasure of examining the shrub in the field, both at Woodburn and Wardell, Richmond River district, New South Wales, in May, 1924, where the plants were found to be in all respects similar to those growing in the neighbourhood of Sydney. The late W. Bauerlen collected a specimen of this Boronia at Wardell as far back as the year 1893. It was of interest to observe all three species, *B. pinnata* (Smith), *B. safrolifera* (Cheel) and *B. thujona,* growing in close proximity to one another at Broadwater, Richmond River, N.S.W.

Boronia Muelleri (Cheel).

Great difficulty was experienced in securing further supplies of the leaves and terminal branchlets of this species, but a small quantity was received on the 9th November, 1925, from Miss C. C. Currie, Lardner, Victoria, through the good offices of the Victorian Forestry Commission. The material received was in full bloom, being the most heavily blossom laden pinnate leaf Boronia, especially at the terminals, which I have handled to date. The flowers were much paler in colour than those of *B. thujona.*

Experimental.

Sixteen lbs. weight of leaves and terminal branchlets on steam distillation yielded 0.6% of highly refracting and fluorescent oil, yellow in colour, and heavier than water. It gave the following results on examination, viz.:—

$d\frac{15°}{15}$, 1.0265; $\alpha_D^{20°}$, +1.50°; $n_D^{20°}$, 1.5150.

Soluble in 0.8 vol. 80% alcohol, Ester No. 20.5.

Ester No. after acetylation, 34.7.

TABLE II.—SUMMARY OF THE ESSENTIAL OILS FROM 4 SPECIES OF BORONIA.

Name of Species.	Yield Oil.	d_{15}^{15}	α_D^{20}	n_D^{20}	Constituents.
Boronia pinnata ... ... (Smith)	0.02 to 0.1%	0.8784 to 0.8917	− 4.7° to − 15.25°	1.4762 to 1.4825	Limonene, *d*-*a*-pinene, sesquiterpene, paraffin
Boronia Muelleri ... .. (Cheel)	0.38 to 0.57%	1.0197 to 1.0265	+ 1.5° to + 3.8°	1.5125, to 1.5150	Elemicin (70−90%), *d*-*a*-pinene, geraniol and geranyl acetate
Boronia thujona ... .. (Penfold and Welch)	0.5 to 0.8%	0.9121 to 0.9152	+ 12° to − 56.54°	1.4526 to 1.4543	α and β Thujone (80−90%), sesquiterpene and paraffin
Boronia thujona... ... .. Var. "A" (from Frazer Island, Q.)	0.5 to 0.6%	1.056	− 8.6° to − 11.2°	1.5255 to 1.5260	Safrol (75−80%), limonene, sesquiterpene, phenolic bodies, paraffin, etc.

The oils from all four species were strongly fluorescent, due probably to the presence of Methyl anthranilate.

23 c.c. on distillation under reduced pressure gave the following results, viz:—

Commenced to distil at 55° (8 mm.).

2 c.c. distilled below 130° (6 mm.).

20 c.c. distilled between 130°-149° (5 mm.) principally at 140°-144° (5 mm.).

	$d\frac{15^\circ}{15}$	$\alpha_D^{20^\circ}$	$n_D^{20^\circ}$
The first fraction had	0.9236	+7.6°	1.4742
and the second	1.0535	+0.6°	1.5212

Determination of Elemicin.—The presence of this phenol ether in quantity (in the crude oil equal to about 90%) was confirmed by oxidation of 16 c.c. with alkaline potassium permanganate according to the procedure outlined in the author's paper on the "Essential oil of *Backhousia myrtifolia*" published in this Journal, Vol. LVI. (1922), page 128. The crystals of trimethylgallic acid, weighing 6 grams, were recrystallised from ethyl alcohol, when they melted at 169-170°. Titration with semi-normal alkali solution showed the acid to be monobasic, with a molecular weight of 213. $C_{10}H_{12}O_5$ requires 212. The ether soluble acid, weighing 2 grams, was recrystallised from ethyl alcohol and melted at 119°-120°. It proved to be trimethylhomogallic acid, as titration with semi-normal alkali solution showed it to have a molecular weight of 227. $C_{11}H_{14}O_5$ requires 226.

The above results confirm those published by the late H. G. Smith in the Proceedings of the Royal Society of Victoria, Vol. XXXII. (1919). The quantity of Elemicin in the later distillation, 90%, was much higher than that referred to in the above publication, 70%. My thanks are due to the Botanists and to the Forestry Departments mentioned in the paper for valuable advice and assistance in the identification and procuring of the plant material examined, and to Mr. F. R. Morrison, A.A.C.I., F.C.S., Assistant Economic Chemist, for much assistance in the chemical examination of the essential oils.

AN EXAMINATION OF DEFECTIVE OREGON (*PSEUDOTSUGA TAXIFOLIA*).

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With Plates XXI-XXIII.

(Read before the Royal Society of New South Wales, 5th Dec., 1928.)

Oregon or Douglas Fir, *Pseudotsuga taxifolia* (Lam.) Britton (*P. Douglasii* Carr), is usually regarded as a strong tough wood and is used extensively in building construction for scantlings, scaffoldings, etc. Recently an Oregon back stay of an electric derrick crane, which was being used in demolition work, broke suddenly and without warning, whilst under load, resulting in a very serious accident. The defective timber was submitted by the Scaffolding and Lifts Branch of the Department of Labour and Industry of New South Wales for examination. Since Oregon is used so largely for purposes in which it is subjected to heavy loads, it was thought advisable to examine the wood fairly thoroughly in order to determine, if possible, the cause of failure. The wood appeared to be quite normal and its external appearance gave no indication of its brittleness.

The broken wood showed a typically brash failure which was almost without splinters and unlike the "long-fibre break" usually obtained for Oregon. Brashness or brittleness is a most serious defect in timber, since under load the wood is liable to fail suddenly and the absence of warning often results in serious consequences; the wood is especially liable to rupture under sudden or impact loads.

The following mechanical tests were made:—

Static bending tests.

Static bending tests on 3″ x 3″ x 36″ span, centre load. The test pieces were cut to this size to include as much as possible of the cross section of the beam, which measured 7.6″ x 6.6.″ Four test pieces were therefore obtained.

	f	E	D	r.p.i.	L.W.	M
1	7000	1,700,000	32.4	6.3	24	14.9
2	9000	1,660,000	33.0	8.5	24	15.1
3	8600	1,730,000	33.1	8.0	27	14.6
4	8000	1,720,000	34.4	9.3	26	14.6
Mean	8150	1,703,000	33.2	8.0	25	14.8

f = Modulus of Rupture in lbs. per sq. in.
E = Modulus of Elasticity in lbs. per sq. in.
D = Weight per cubic foot at time of testing; air dry volume and weight.
r.p.i. = Average number of growth rings per inch.
L.W. = Percentage of late or summer wood in the growth ring.
M = Moisture percentage on the dry weight.

The proportional limit was not clearly defined in tests. The failures were carroty and the wood failed in tension without warning.

Two static bending tests were made on the full-sized timber with a span of six feet, centre loading.

	f	E	r.p.i.	L.W.	M
1	4890	1,570,000	Max. 10	26.2	14.5
2	7680	1,570,000	Min. 5		15.0
Mean	6285	1,570,000	8.5	——	——

The proportional limit was not defined. The failures were sudden, partially in tension and horizontal shear, and definitely indicated the brashness of the wood.

Additional static bending tests were made subsequently, on 2″ x 2″ x 28″ span*. It will be noted that the moisture content has decreased.

f1	f	E	W.	W. to M.L.	D.	r.p.i.	L.W.	M.
7350	7930	1,870,000	1.58	2.08	32.0	8.0	24.3	13.0
7980	8820	1,890,000	1.87	2.58	32.2	9.0	28.4	12.8
7350	7480	1,810,000	1.63	1.94	32.3	8.0	28.0	12.3
7140	7715	1,580,000	1.79	2.40	31.3	6.5	24.8	12.7
7455	7990	1,790,000	1.72	2.25	31.9	7.4	26.4	12.7

f1 = Fibre stress at proportional limit in lbs. per square inch.

W. to P.L. = Work to proportional limit in inch lbs. per cubic inch.

W. to M.L. = Work to maximum load in inch lbs. per cubic inch.

For comparison the results of the following static bending tests are given, made on small clear specimens from the Technological Museum.

3″ x 3″ x 36″ span centre load.

	f	E	D.	r.p.i.	L.W.	M.
1	11,620	2,260,000	34.7	16.0	39.6	12.4
2	12,660	2,330,000	35.2	20.5	36.9	12.6
3	13,580	1,670,000	34.2	12.0	34.5	11.3
4	13,060	2,010,000	32.7	12.5	28.6	10.9
5	10,520	1,800,000	36.5	6.5	38.4	12.4
6	8,400	1,770,000	33.2	4.0	35.8	11.9
7	7,660	1,330,000	26.4	4.0	25.2	12.0
Mean	11,070	1,800,000	33.3	11.0	31.4	11.9

The following static bending tests were made on 2″ x 2″ x 28″ span clear specimens.

* Tests marked * have been made in conformity with the specification adopted for testing small clear specimens of timber and described in U.S.D.A. Forest Service Bull. 108, and subsequently in Projects I. of the Canadian Forest Product Laboratory and also of the Department of Scientific and Industrial Research, Forest Products Research, of Great Britain, 1928.

	f	E	D	r.p.i.	M
Maximum ..	14,730	2,350,000	35.6	35	14.2
Minimum ..	8,800	1,290,000	24.8	17	9.8
Mean 12 tests	11,520	1,790,000	31.9	22.3	12.3

Canadian[1] and American[2] mean tests for static bending tests on 2″ x 2″ x 28″ span air dry clear specimens are as follows:—

		f1	f	E	W. to P.L.	W. to M.L.	D+	r.p.i.	L.W.	M.
Mountain	(1)	8,460	13,340	1,664,000	2.44	8.40	31.4	26.2	25.0	9.5
Mountain	(1)	9,540	13,620	1,806,000	2.86	11.80	33.2	17.4	32.0	10.7
Coast	(1)	8,990	14,050	2,142,000	2.20	9.90	33.4	13.3	38.0	11.1
Wyoming	(2)	6,900	10,300	1,460,000	1.83	6.5	33.6	22.0	27.0	9.4
Oregon	(2)	10,600	14,000	2,210,000	2.94	8.4	38.1	13.0	35.0	6.2
U.S.A.	(3)	5,065	6,777	1,853,000	——	——	31.0	12.2	41.0	14.9

(1) Some Commercial Softwoods of Canada. Forest Service Bulletin No. 78, Dept. of Interior, Canada, 1927.

(2) Mechanical Properties of Woods grown in U.S.A. Newlin and Wilson, U.S. Dept. of Agric. Forest Service, Bull. 556, 1917.

(3) Mean figures for 5″ x 8″ beams. Tests on Structural timbers. Cline and Heim, U.S. Dept. of Agric. Forest Service, Bull. 108, 1912.

+ Corrected to 12% moisture.

Impact Tests.

Izod impact tests were made in conformity with the British Engineering Standard Association Specification for Aircraft Material.

	Energy absorbed in foot lbs.	r.p.i.	M
Maximum	15	9	—
Minimum	2	7	—
Mean 6 tests	8.3	7.8	15%

Tests made on Oregon in stock gave the following results:

		r.p.i.	M	D
Maximum	28 ft. lbs.	35	11.3%	34.2 lbs.
Minimum	17.5 „ „	12	9.8%	25.4 „
Mean (12 tests) ..	23.0 „ „	22	10.6%	31.2 „

******Compression parallel to grain.*

	C1	C	E	r.p.i.	M
Maximum ..	5,500	7430	1,250,000	9	—
Minimum ..	3,875	6230	833,000	6.5	—
Mean (6 tests)	4,685	6695	999,000	8.5	12.7

C1 = Fibre stress at limit of proportionality in lbs. per square inch.

C = Maximum crushing strength in lbs. per square inch.

Canada (*l.c.*) ..	4220	7600	2,229,000	19	10.4
U.S.A. (*l.c.*) ..	7290	8885	——	17.5	7.8

******Compression perpendicular to grain.*

Fibre stress at limit of proportionality in lbs. per sq. in.:

		r.p.i.	
Maximum	1440	8.5	—
Minimum	1325	6.0	—
Mean (5 tests)	1370	7.0	12.7%
Canada (*l.c.*)	997	19	10.4
U.S.A. (*l.c.*)	860	17.5	7.8

Tension parallel to grain.

	Area in sq. in.	Breaking Load in lbs. per sq. in.	r.p.i.	M
1	0.7651	3850	9.0	14.1
2	0.7543	6995	9.0	12.8
3	0.7466	7640	7.0	14.1
4	0.7698	8060	10.5	12.9
	Mean	6636	9.0	13.5

Koehler† gives the following mean figures for tension parallel to grain.

1. 16,200 lbs. sq. in. M = 24.1% D = 33 lbs.
2. 13,300 lbs. „ „ M = 23.0% D = 30 lbs.

† Koehler Properties and Uses of Woods, 1924.

**Tension perpendicular to grain.*

	T(a)	T(b)	r.p.i.(a)	r.p.i.(b)	M
Maximum	300	470	7.5	9	—
Minimum	115	272	6.5	6.5	—
Mean (7 tests) ..	177	305	7.2	7.8	12.7

T = Tensile strength in lbs. per sq. in.
(a) = Plane of failure radial.
(b) = Plane of failure tangential.

	(a) & (b)		
Canada (*l.c.*)	539	19	10.4
U.S.A. (*l.c.*)	330	17.5	7.8

**Hardness.*

	H(a)		H(b)		H(c)
Maximum	600		610		660
Minimum	505		550		780
Mean (7 tests) ..	548	(5 tests)	589	(7 tests)	716

H = Load required to imbed a 0.444 inch ball to half diameter.
(a) = Radial surface; (b) = tangential surface; (c) = end surface.

Canada (*l.c.*) ..	683			691	799
U.S.A. (*l.c.*) ..		(a) & (b)	575		670

**Shearing Strength parallel to grain.*

	(a)	(b)	r.p.i. (a)	r.p.i. (b)	M
Maximum ..	1490	1420 lbs. per sq. in.	8	10	—
Minimum ..	812	1030 „ „ „ „	6.5	6	—
Mean (6 tests)	1190	1266 „ „ „ „	7.3	8.1	12.7%

(a) Plane of failure radial.
(b) Plane of failure tangential.

Canada (*l.c.*) ..	(a) & (b)	1271	19	10.4
U.S.A. (*l.c.*) ..	(a) & (b)	1140	17.5	7.8

**Cleavage*.

			r.p.i.		
	S(a)	S(b)	(a)	(b)	M
Maximum	190	140	9.0	8.0	—
Minimum	120	160	6.5	6.5	—
Mean (6 tests) ..	141	152	7.4	7.3	12.7

S = Splitting Strength in lbs. per in. of width.
(a) = Plane of failure radial.
(b) = Plane of failure tangential.

Canada (l.c.) ..	(a) & (b)	265	19	10.4
U.S.A. (l.c.) ..	Cleavage tests for air dry wood not given.			

One of the most important requirements in a timber which is subject to loads is toughness†. The term is applied to a number of different properties of wood, but can be regarded as the reverse of brittleness; it is indicated by (a) the ability of the wood to absorb energy in impact tests, (b) the work to maximum load in static bending tests.

An examination of the results of the static bending tests shows that the modulus of rupture is small in comparison with the other tests on small clear specimens, but the figure is not abnormally low. The most striking result is the small interval between the proportional limit and the ultimate load, which is a definite indication of brittleness. Further, although the resilience of the wood is normal, the "work to maximum load" is very low, indicating again a brittle timber. Similarly, the impact tests, with an

† Den Berger, Mechanical Properties of Dutch East Indian Timbers, No. 12. Proefstation v/h. Boschwezen, 1926, refers to a tough wood as "one that will not rupture until it has deformed considerably under loads at or near its maximum strength or one which still hangs together after it has been ruptured and may be bent back and forth without breaking apart, and which gives way only gradually and gives warning of rupture. It is able to store a considerable amount of energy and has a remarkable shock resisting ability."

energy absorption of 8.3 foot lbs. in comparison with 23.0 foot lbs. for normal Oregon, clearly show the brashness of the wood.

Except that the wood failed, almost without warning and with no defined limit of proportionality, the large beam tests did not reveal any serious lack of strength, in comparison with large beam tests made in U.S.A.

The stiffness of the wood, indicated by the modulus of elasticity, was not low in comparison with many other of the test results.

Tests made in compression parallel to the grain showed that the wood was not particularly weak in this regard, and that there is a very appreciable difference between the limit of proportionality and the ultimate load, although less than that given for the Canadian tests.

The strength in compression perpendicular to the grain was higher than the means given by other authorities and seems to indicate that the ability of the tracheids to withstand lateral crushing is not weakened, however brittle the wood might be.

As Record* states, the tensile strength, parallel to the grain, of a wood is about three times its strength in compression, but the results of the tests show that there is practically no difference in the figures for tension and compression obtained for the defective Oregon, whilst the results given by Koehler (*l.c.*) clearly show the very great superiority in tensile strength of normal Oregon. It is easy to understand, therefore, that whilst with normal wood it is possible to bend it considerably before failure takes place on the tension side, in wood which has the tensile strength approximately equal to the compressive strength, very slight bending is sufficient for the wood to fail on the tension side and the wood is therefore brittle.

* Record, Mechanical Properties of Wood, 1914.

The results of the tension perpendicular to the grain, with a radial plane of failure are low and indicate a small degree of lateral cohesion between the tracheids or that the cell walls are easily split when subjected to a transverse pull. The greater strength in tension in a radial direction, i.e., with a tangential plane of failure, is apparently due to the action of the medullary rays.

The hardness tests, whilst lower than the Canadian tests, are close to those for the U.S.A. wood, for the side, and higher for the end, and show that the wood was not soft or spongy. As pointed out by Record (*l.c.*) resistance to indentation is largely dependent on density.

The results of the shearing tests parallel to grain are quite normal and do not indicate any weakness in this respect.

Strength to resist splitting, as indicated by the cleavage tests, is comparable with tension perpendicular to the grain. The results of this series of tests (i.e., cleavage) are also low in comparison with the Canadian figures.

Weight.

One of the most important factors influencing the strength of timber is weight. In practice, weakness in timber is usually associated with a low density and relationships have been established between the various mechanical properties of wood and specific gravity* †.

The density of the defective wood, about 33 lbs. per cubic foot, is not low and compares closely with the average figures given for the material tested in Canada and U.S.A., and it also approximates to the mean of the specimens

* The relation of the shrinkage and strength properties of wood to its specific gravity. Newlin and Wilson, U.S. D.A. Forest Service Bull. No. 676, 1919.

† Den Berger (l.c.) outlines the various theories in reference to the mechanical properties—density relationship.

tested for comparison. There was no evidence of compression wood, which is comparatively weak. Den Berger (*l.c.*) has pointed out that specific gravity does not give any clue to the pliability or toughness of the wood and this is borne out by the result of the impact tests.

Rate of Growth.

From a large series of tests on structural sizes made in U.S.A.‡ the optimum rate of growth for Oregon was found to be 24 rings per inch, but considerable variation in strength was found, and the conclusion was reached that "rings per inch are not a reliable index to the mechanical properties of timber, especially structural timbers containing knots and other defects." Further, in particular reference to Oregon, the following conclusion was made that, "in general, rapidly grown wood (less than eight rings per inch) is relatively weak. A study of individual tests upon which the average is based shows, however, that when it is not associated with light weight and a small proportion of summer wood, rapid growth is not indicative of weak wood".*

In the crane backstay the maximum number of rings per inch is 10, and the minimum 5, the mean being 8.5, which, though showing comparatively rapid growth, is not exceptionally fast. The American Society for Testing Materials has adopted as a standard for the best grade, known as Dense Douglas Fir, that it shall have an average of not less than 6 rings per inch and at least ⅓ summer or late wood, or if the rings are wide the summer wood must constitute at least ½ of the ring†. Tests (5), (6) and (7)

‡ Tests on Structural timbers. U.S. D.A. Forest Service Bull. No. 108.

* Properties and Uses of Douglas Fir. U.S. Forest Service Bull, No. 88.

† Basic Grading Rules and Working Stresses for Structural Timbers, Newlin and Johnson, U.S. Forest Service Circular No. 295, 1923.

made on 3″ x 3″ x 36″ clear specimens were selected from rapidly grown material; (6) and (7) with 4 r.p.i. are comparable in strength with the results for the small clear specimens from the defective wood. Both (6) and (7) were cut from near the heart, and showed brittle failures. Although the position of the heart is not regarded as affecting the strength in structural sizes, provided the weight is normal, it is commonly found that wood near the heart, either due to very rapid growth or incipient decay is liable to be brittle. The inner side of the crane section was cut approximately 3 inches from the heart.

Slow growth also frequently results in a weak timber, one of the Museum test pieces with 35 r.p.i. had a density of only 25.4 lbs. and gave a modulus of rupture of 8,800 lbs. per square inch.

Late Wood.

The percentage of late or summer wood in the growth ring has an important bearing on strength since a low percentage usually indicates brashness. The average figure of 26% obtained is rather lower than the specification for "dense" Oregon of 33%, but is not low enough to account for the brittleness of the wood. Forsaith,* in his investigation of brashness, found that it was increased by a decrease in the amount of late wood, by a decrease in the thickness of the tracheid wall, and by an increase in the number and size of the bordered pits. He found also that fibre or tracheid length was unimportant in determining brashness. Since obviously increased cell wall thickness must result in increased weight, if the weight is normal one would not expect to find thin tracheid walls. Observations made on the radial thickness of the tracheid wall are as follows:—

* Forsaith, C. C., The morphology of wood in relation to brashness. Jour. Forestry, xix, 237, 1921.

Portion of beam near heart	Early Wood	=	2	–	3 μ
	Late Wood	=	5	–	7.5 μ
Middle of beam	Early Wood	=	2	–	3 μ
	Late Wood	=	5	–	9 μ
Museum 3″ x 3″ test No. 1	Early Wood	=	2	–	4 μ
	Late Wood	=	5	–	8 μ

It is evident that the cell wall thickness is comparable with the ordinary wood. The length of the tracheids is very variable, but the majority were between 2.4 – 5.0 mm., which is also normal for Oregon.

Moisture.

Although wood dried to a very low moisture content is liable to become brittle, the moisture content of the crane material is normal for air-seasoned material and cannot have had any effect in bringing about the extreme brashness of the wood.

A microscopical examination showed no evidence of fungal attack nor was the wood discoloured in any way. Although wood may become brittle in areas adjacent to those in which the hyphae are actually present, the fact that test pieces from all parts of the beam showed similar brashness does not suggest the possibility of a fungal origin of the trouble.

Robinson†, who has made a very careful microscopical study of the initial causes of failure in timber, found definite indications of minute slip planes, in the cell walls, especially in compression. These gave cellulose reactions with various reagents. He further concluded that the formation of these slip planes preceded the buckling or crinkling of the tracheids.

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† Robinson, W. The microscopical features of mechanical strains in timber and the bearing of these on the structure of the cell wall in plants. Trans. Roy. Soc., London. Vol. 210, 49, 1920.

From the photomicrographs of sections from the compression side of the failure it is apparent that there is no sign of buckling of the tracheids. Although aniline chloride, followed by aniline blue, indicates minute lines on the cell wall, apparently corresponding to the slip planes described by Robinson, these appear just as numerous in wood which, as far as is known, had not been subjected to any severe strains. Chlor-zinc-iodine and iodine and sulphuric acid gave no appreciable darkening of the tissues in the vicinity of the zone of failure.

Nothing unusual was observed in the number or distribution of the bordered pits.

The failure appeared to be almost transverse in the late wood, the tracheids being broken almost at right angles. In places the fracture followed the rays; in others it occurred along the grain in the middle of the late wood. Many of the tracheids showed a break inclined at an angle of about 45°, the plane of maximum shear, whilst others were inclined at greater or lesser angles to the longitudinal direction.

The extreme weakness of the wood in tension, which approximates that in compression, evidently accounts for the lack of buckling of the fibres in compression, since the failure apparently occurred first on the tension side.

In the position in which the wood was used it was subjected to variable eccentric loading and the compressive and tensile stresses alternated from side to side, with the alteration of the position of the jib. The wood was apparently subjected to loads approaching, if not exceeding, the elastic limit and the continuous reversal of stresses suggests the possibility of fatigue.

Although fatigue is not usually regarded as seriously affecting timber, Siminski, according to an abstract†, has proved that wood previously subjected to compression is rendered weaker in tension and that reversal of stresses materially lowers the resistance of the wood to rupture. On the other hand, repeated impact tests were made on wood at the Forest Product Laboratory, Madison**, in which the specimens were stressed to a little above the elastic limit; the wood was then subjected to a static bending test and the results in comparison with similar specimens which had not been subjected to impact showed no significant change in the properties of the wood.

There seems to be no reason why modification of the tissues of the wood should not occur as the result of severe stresses, ultimately resulting in weakness or brashness. The subject appears to be worthy of further investigation.

I am indebted to Prof. H. P. Brown, of the New York State College of Forestry, Syracuse University, for the above references.

Summary.

Tests showed that the wood was extremely brittle and failed without warning. Whilst the strength in compression is normal it is extremely weak in tension parallel to the grain.

The ability of the wood to absorb energy is very small, rendering it unfit for the purpose for which it was used. Although the rate of growth is faster than the optimum for Oregon and the percentage of late wood is rather less than is permitted in first-grade timber for structural purposes, the density of the wood is normal. It is suggested,

† Siminski I Vestnik Ingenerov, No. 4, April, 1927. Abstract seen in Mechanical Engineering, Vol. 49, 802, 1927. Original not available.

** Moore and Kommers. The Fatigue of Metals, Chap. X., 1927.

however, that wood of rather slower growth and cut further from the heart should be used for purposes where it is known that the member will be subjected to severe stresses.

Microscopically, there appears to be no reason to account for the brashness, which is apparently due to some inherent quality of the wood or possibly to a state of fatigue brought about by continual reversal of stresses near the elastic limit.

In conclusion, I am indebted to the Mechanical Engineering Department of the Sydney Technical College for making the large beam tests; to this Department and to Wing-Commander Wackett, R.A.A.F., Experimental Station, Randwick, for the use of the necessary machines; and to Mr. F. B. Shambler, of the Museum Staff, for his assistance in the making of the tests and for the two photographs illustrating the fracture and cross section of the wood.

EXPLANATION OF PLATES.

Fig. 1. Transverse section of timber, showing nature of wood and distribution of growth rings.

Fig. 2. Original failure of the crane backstay. The right is the compression side of the member. The brittleness of the wood is indicated by the "short-fibred" break.

Fig. 3. Radial longitudinal section, showing break on compression side; the fracture is frequently transverse in the late wood. $\times\ 11\frac{1}{2}$.

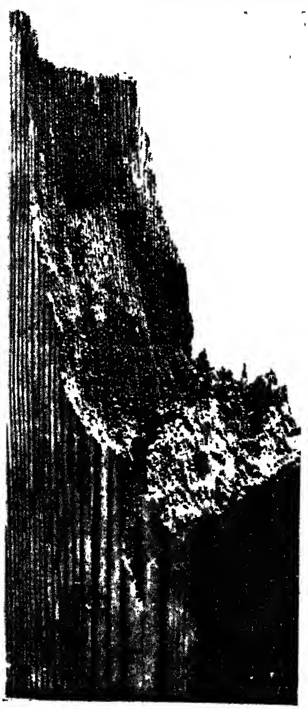
Fig. 4. Tangential longitudinal section, showing break on compression side. $\times\ 11\frac{1}{2}$.

Fig. 5. Radial longitudinal section of break on compression side, showing inclination of fracture of the tracheid walls. The spiral bands are normal in Oregon. Note absence of buckling of the tracheids. $\times$ 125.

Fig. 6. Similar section to above at junction of early and late wood. The transverse fracture of many of the late wood tracheids is apparent. In the spring or early wood the failure frequently but not always follows the line of the bordered pit. Fine markings can be observed on the walls of some of the late wood tracheids. $\times$ 125.

Fig. 7. Tangential longitudinal section of break on compression side in early wood, showing irregular fracture of the tracheids; these commonly occur at the same inclination as the spiral tracheid thickenings. $\times$ 125.

Fig. 1.



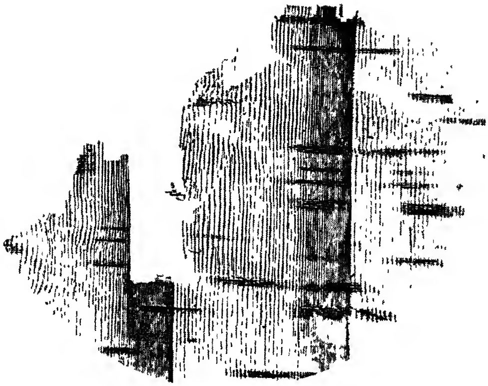


Fig. 3.

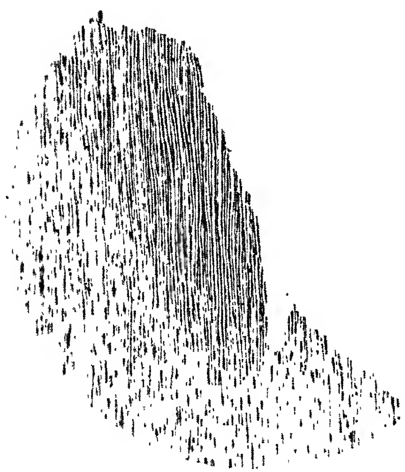
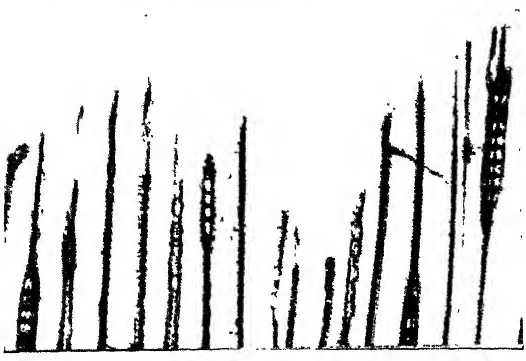


Fig. 4.

Fig. 5.

Fig 6



ON THE PROBABLE TERTIARY AGE OF CERTAIN NEW SOUTH WALES SEDENTARY SOILS.

By W. R. Browne, D.Sc.,
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(Read before the Royal Society of New South Wales, Dec. 5, 1928.)

In his presidential address to this Society in May, 1927—a noteworthy contribution to Australian geological literature—Dr. W. G. Woolnough advanced a bold, but interesting and stimulating, generalization as to the origin of the various hard surface-cappings, comprised by him under the name of duricrust, which are such a common feature in certain parts of our continent. Some of the conclusions he expressed in regard to the origin and date of formation of the duricrust might well be extended to other surface accumulations which are still unconsolidated, in other words, to some of our present-day soils.

The residual sedentary soil is the result of rock-weathering *in situ*. As a rule, but a small thickness of the surface rock is affected directly by the atmospheric agents of weathering, but, indirectly, through percolating water-solutions and the gases they contain, rocks may be influenced chemically for considerable depths below the surface, and it is to this chemical weathering that the sedentary soil is mainly due, the percolating solutions having removed the readily soluble rock constituents, leaving the oxidised and hydrated insoluble residues as a discompacted or potentially incoherent mass.

In general there is a tendency for the products of weathering to be removed by erosion, this tendency increasing, in the case of normal water-erosion, with the surface relief,

and there is pretty general agreement that the accumulation of a deep mantle of soil and subsoil is not favoured by youthful topography. In regard to the conditions most favourable for such accumulation, however, there does not appear to be the same unanimity among geologists.

Barrell[1], in his classic paper on "Rhythms and the Measurement of Geological Time," challenges what he evidently regards as an accepted view, that peneplains should be covered with a very deep residual oxidised soil. On the contrary, he declares, a peneplain should possess a relatively thin regolith, since beneath its surface there should be practically no groundwater circulation, and for effective rock-decay this circulation is imperative, otherwise the solutions soon get saturated and chemical action ceases. According to Barrell, in a region of considerable relief, where the circulating ground-water has greater rapidity of movement, a greater volume of rock is likely to be affected.

Van Hise[2], discussing the physiographic conditions favouring chemical weathering, points out that where the elevation is slight the water-table, the downward limit of effective weathering, may be very close to the surface, so that the depth of decomposition is very restricted; at the same time decomposition will be very thorough. Since in regions of high relief disintegration and erosion may go on too rapidly to permit much decomposition, Van Hise concludes that the most favourable topographical conditions for the accumulation of decomposed rock material are those of moderate elevation and continuous moderate slopes.

Woolnough in his presidential address emphasises very strongly the connexion between peneplanation and deep decomposition, and even goes so far as to declare that "one essential criterion of a high degree of perfection of peneplanation is that the rocks of the area show evidence of

very deep and very complete chemical alteration by meteoric waters." Woolnough's argument is that only when a region is in an advanced stage of peneplanation will mechanical transport of weathered material cease, while at the same time the sluggish lateral circulation of surface waters will involve "deep saturation of the subsoil and long-continued contact between rock-minerals and meteoric waters."

There is thus evident quite a marked conflict of opinions in regard to the question of the conditions favouring deep decay.

It is clear that in a peneplain the water-table will be close to the surface, and, if the contention of Van Hise be accepted that the belt of weathering extends only down to or a little below the water-table, then it is difficult to see how any considerable thickness of decomposed rock-material can accumulate. On the other hand it is certain that, where there is appreciable relief, not only will the proportion of meteoric water soaking into the ground be considerably lessened, but the removal of the products of weathering will proceed rapidly through erosion, and the net rate of accumulation of weathered material will be slowed down: at some critical degree of relief the products of weathering will be removed by erosion as fast as they are formed.

The accumulation of residual sedentary soil, then, depends on the ascendency of chemical weathering over mechanical erosion, but whether the maximum result will be attained when the relief is moderate or when it is negligible it would be very difficult to say, especially as other factors besides physiography come into play.

The inference, however, may safely be made that low physiographic relief is favourable to the accumulation of much residual sedentary soil and decomposed rock, and, modifying Woolnough's thesis slightly, we may say that

where thick layers of soil, subsoil and decomposed rock are found, that fact is in itself evidence of very mature physiographic conditions having prevailed during their formation. If therefore we find such accumulations in areas of present-day marked relief or of youthful or early-mature dissection, it is a fair inference that we are dealing with fossil weathering, as it were, and with fossil soils, not now in a state of active formation, but produced in, and surviving from, the closing stages of the last preceding cycle of erosion.

For many years past the writer has at times encountered what have seemed to be evidences of such sedentary soils in various parts of the uplifted and dissected peneplain of central-eastern New South Wales. Mr. E. C. Andrews(3) has pointed out that this region, in common with the rest of Eastern Australia, was a peneplain, or at all events an area of low relief, in late Tertiary times, and that by a series of differential uplifts in the late Pliocene period, during what he has called the Kosciusko epoch, it was raised to varying heights above sea-level, since which time the plateaux formed have been suffering dissection. In some places, as round about Sydney and in the Blue Mountains, the present drainage-system is fairly complete, through the evolution of new streams or the rejuvenation of old ones. Elsewhere rejuvenation has not proceeded so rapidly, and above the rejuvenation-limit of the streams areas are to be found, which, though high above sea-level, still preserve almost intact the mature topography and gently undulating physiographic features of their late Tertiary days.

On the flat tops of the residual surface of the plateaux, and on the very gentle slopes of the former mature valleys, there are to be found the soils, sometimes of quite notable depth, whose formation the writer considers took place before the Kosciusko uplift; instances of these will now be given.

Around Sydney the dominant geological formations are the Triassic Hawkesbury Sandstone and Wianamatta Shale. Where the former occurs as ridges forming water-partings between adjacent streams the soil-covering is usually but scanty, the sand having been displaced down the valley-slopes by gravity and sheet-wash erosion, or altogether removed by the streams. But where there are flat tops, however narrow, to these ridges, a layer of sandy soil and subsoil may be apparent, sometimes three feet and more in depth, grading down through decomposed sandstone into the solid rock. The depth of the soils would appear in some degree to vary according to the extent of flat country, and in places, as about St. Ives and French's Forest, where considerable flat and relatively still undissected areas occur, the soils are of extensive distribution and substantial depth. An interesting feature is sometimes to be noticed near the boundaries of Hawkesbury sandstone and overlying Wianamatta shale. The shale may have completely disappeared as such, and the soil rests on sandstone, but this soil is of a clayey or loamy character quite unlike that derived from the sandstone, and is characterised by the presence of little flat fragments of rather ferruginous sandy shale. This soil is regarded as an inherited type, representing the weathering-product of a former thin layer of shale which has now completely disappeared.

The Wianamatta Shale itself around Sydney occupies perhaps mainly the lower-lying areas, where uplift has been small and relief is still but slight. Here there has been weathering to considerable depths, as may occasionally be seen in railway-cuttings and in other excavations in the more southerly suburbs, where the deep iron-stained clayey soils and subsoils are usually very characteristic. On the higher lands the shale soils are perhaps shallower, but in flat or gently sloping situations the thickness is greater, and the soil, particularly, it would appear, near the base of the

formation, is of a dark red colour and very ferruginous. A common characteristic of these dark shale soils is the presence of irregular nodules of ironstone, sometimes up to a couple of inches in diameter, but generally smaller. These may be quite thickly embedded in the soil, or where the finer-grained soil has been washed away they may form a thin capping of the so-called "ironstone gravel." There is little doubt that these nodules have been formed in the soil itself, and their significance will be referred to presently. A good place in which to study an occurrence of this kind is on the road from Pymble to St. Ives, near the Pymble golf-links; the "ironstone gravel" has been observed at Roseville and elsewhere.

Recently, under the guidance of Mr. G. D. Osborne, B.Sc., the writer has had the opportunity of examining some of the dissected plateau surface about the suburbs of Arncliffe and Earlwood, to the north-west of Botany Bay. The peneplain has been uplifted here to a height of about 150 feet above sea-level, and has been dissected by Cook's River, Wolli Creek and their tributaries. The area in question is composed of Hawkesbury Sandstone, and in numerous places on the level upland surface—in fact everywhere except on the gentle slopes near the tops of the valley-walls whence erosion has removed it—may be seen a variable thickness of rather sandy soil, containing, or underlain by, abundant irregular nodules of brown ironstone, sometimes aggregated into a solid layer on top of the sandstone. In certain places the soil resting on the sandstone is very dark red in colour and contains the little flat flakes of rock described above as characteristic of the shale soils. Where only nodules or flat flakes are found on the solid rock the evidence is very clear that a layer of soil has disappeared. According to Mr. Osborne the ironstone nodules are universally distributed over the plateau surface around these suburbs.

On the Blue Mountains, about Leura particularly, somewhat similar phenomena have been observed. On the flat tops of the sandstone plateau depths of soil of a couple of feet and more may be encountered. It is essentially sandy, somewhat mealy in texture and feel, and brownish in colour through iron-staining, and it merges imperceptibly into decomposed sandstone. Sometimes the decomposed rock is to be distinguished from soil only by the existence in it of bands of little quartz pebbles representing pebble-layers in the original rock which are still in place. The mealiness and the greater depth of decomposition as compared with the Sydney sandstone, are in all probability the result of a higher felspathic content of the sandstone, due to Leura being much nearer than Sydney to the original granitic source of supply for the clastic material.

The sandstone is intersected with highly irregular layers rich in iron oxide, averaging about an inch in thickness. The ferruginous material has been deposited in the pores of the sandstone and forms a resistant cement. On the weathering of the sandstone into sedentary soil these layers are broken up into fragments and remain embedded in the soil, and where the soil is dug up, or where it has been eroded along street gutters, smooth rounded or kidney-shaped nodules of a yellow-brown colour may be seen, which, on being broken open, are found to consist of fragments of the ferruginous sandstone layers which have been completely invested with a coat of iron hydrate. There seems no reason to doubt that these nodules, like those at Pymble, Arncliffe and elsewhere, have been produced in the soil, in this case by deposition round a nucleus of ferruginous sandstone.

The country about Penrose, Wingello and Tallong, in the southern part of the Central Tablelands, is in part dissected by the tributaries of the Shoalhaven River, but there are

considerable areas, above the rejuvenation-limit of the streams, which are almost in their pre-uplift condition of late maturity, and these are covered with an extensive mantle of sandy and gravelly soils, overlying sandstones of Triassic, and conglomerates and sandstones of Upper Permo-Carboniferous age. Though in the depressions this soil may be in great measure alluvial, by far the greater part is sedentary. Some of the country is covered with flows of Tertiary basalt, and there is evidence that some of this was poured out over sandy soil resting directly on the older sandstones, just as in the case of the silicified Tertiary sands at Ulladulla described by Miss Ida A. Brown, B.Sc.(4) In railway-cuttings the gradation from soil into rotten, and from that into fresh sandstone, is well displayed. At Tallong, and particularly at Wingello, the writer was much struck by the resemblance of the soil conditions to those prevailing in the Blue Mountains, thick deposits of white sand often constituting a surface-layer, the bleaching being probably due to the action of organic acids produced from decomposing vegetation. At Wingello, though definite proofs were not found, it appeared to be the case that the deposits of Tertiary pisolitic laterite or bauxite were in part resting on this sandy soil, and in the neighbourhood of Penrose Mr. G. F. K. Naylor, B.Sc., pointed out a thin bed of dark red ferruginous shale containing Tertiary fossil leaves, which was underlain by compact sandy soil.

At Ulan, about 25 miles north of Mudgee, there are coal-measures resting directly on granite, and overlain by Triassic sandstones and conglomerates. The country is less than 2000 feet above sea-level, and is drained by the River Goulburn, which here flows in a mature valley perhaps 300 feet below the plateau-level. The country is of moderate relief, and the surface of the plateau is nearly

flat over large areas. A noteworthy feature of the Triassic country in places is the thick covering of sandy soil, very similar to that found in some of the localities described above.

That the soils to which allusion has been made are of Tertiary age is the conclusion to which the writer has been impelled, partly from the theoretical considerations put forward in the early part of this paper. The areas described were all affected by the Tertiary peneplanation, and before the Kosciusko uplift were in a state of advanced maturity or senility; the probability must therefore be recognised that a thick mantle of decomposed rock and sedentary soil covered them before the uplift. Since that time in a number of the places described there has been no considerable change in the local base-level of erosion, and removal of the products of decay by surface-erosion is proceeding but slowly, hence it is reasonable to expect to find considerable quantities of Tertiary regolith still remaining. At the same time in the instances cited the present-day relief is sufficient to ensure good underground circulation, and good surface drainage, so that the stream-erosion could easily keep pace with current weathering. The existing accumulations of soil, representing the excess of material produced by weathering over that removed by erosion, are therefore not to be attributed to present-day weathering activity, but are more reasonably interpreted as relics of the Tertiary regolith.

But it may be objected that while such soils may have persisted till the present day in inland areas as yet not reached by rejuvenation, such a thing would be impossible about Sydney and the Blue Mountains, in view of the state of dissection attained by the uplifted peneplain, and the likelihood of all unconsolidated deposits having been swept away long ere this. It must, however, be remembered in

this connexion that since Pleistocene times, when most of the existing dissection was accomplished, there has been a considerable diminution in the rainfall and a corresponding shrinkage of the streams. Any parts of the plateau area, therefore, which were untouched by erosion during the more pluvial period, may easily have survived till the present, and where the actual soil has been swept away the original subsoil and decomposed rock may exist to-day as soil.

Of course, too, the soils dealt with are in the main sandy, and as such would be less liable to surface erosion than more compact types: in other words their porosity has been a chief factor in their survival. As a matter of fact the fine-grained clayey soils have in many cases almost completely disappeared through sheet-wash erosion from the flat or nearly flat plateau surfaces.

Again, the frequent occurrence of ferruginous nodules and of hardpan in the soils of the plateau areas is of significance. The deposition of material of this kind is to be regarded as a manifestation of bad underground drainage, combined with an alternation of wet and dry climatic periods. The lack of drainage ensures that the stagnant soil-water will be saturated with mineral matter, which is deposited in the soil or subsoil as nodules or hardpan during periods of drought. Woolnough has shown the probability that conditions favouring such deposition existed during our last great peneplanation, possibly during the Miocene period, and although the Miocene climate in Eastern Australia may not have been tropical, with alternations of dry and wet seasons (as he postulates for Western Australia), still it must be remembered that our coast-line was then much further to the east than at present, and that therefore the region of Sydney and the Blue Mountains may have been subject to occasional droughts such as afflict our present inland areas; these irregularly recurring

dry spells would act in the same way, though not to the same degree, as the regular dry seasons of the tropics, in promoting hardpan formation.

Since both the climatic and the physiographic conditions obtaining at present must be regarded as utterly unfavourable to the deposition of hardpan, its widespread distribution in the soils, both sandy and clayey, must be taken as indicative that these soils are Tertiary, and where the ironstone nodules are resting as a "gravel" directly on the rock-surface of the plateau they are to be interpreted as survivals, through superior grainsize and weight, from sandy or clayey soils which are now no more.

Much of the nodular material is loose and unconsolidated, being in that respect unlike the more compacted and often very solid laterite of Western Australia, and although in places, as about Waterfall and National Park, it may occur as a somewhat compact, rather sandy, aluminous ironstone, it is doubtful whether this was ever formed right at the surface; rather is it to be regarded as a kind of nodular hardpan formed like the ironstone "gravel" below the surface in the subsoil or the deeper parts of the soil, the upper parts of which have now largely disappeared through sheetwash erosion.

The Wingello bauxites, or laterites rather, are possibly to be placed in a different category.

It is difficult, if not impossible, to explain these plateau ironstone "gravels" and hardpans on any other hypothesis than that they are remnants of the regolithic mantle of a Tertiary landscape.

In the foregoing observations only those areas have been dealt with which have come under the writer's personal notice, and it is of course not suggested that all our sedentary soils are Tertiary. In fact, physiographic and other

conditions eminently suitable for the accumulation of soil-material in place exist at the present day, as for example:

(1) in some of the less elevated, physiographically mature parts of the State west of the Main Divide, where the rainfall is not too low;

(2) in those parts of our coastal regions which have been worn down to a low level since the Kosciusko uplift, or have never been raised much above sea-level; and

(3) on the floors of the broad valleys of rivers such as the Wollondilly, Cox, Hunter, and others, scooped out and widened since the Kosciusko uplift.

Nevertheless it seems not improbable that the suggestions made as to the date of formation of certain soils may have a very much wider application in this State; for, since the prolonged period of Tertiary peneplanation and low physiographic relief must have left its legacy of deep decomposition over a very large area, it is to be expected that the residual deposits will still appear as sedentary soils and areas of deeply decomposed rock, not merely in those portions of the State which have suffered little from elevation, but also on the less dissected portions of the highlands.

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THE ESSENTIAL OIL OF A NEW SPECIES OF ANEMONE LEAF BORONIA RICH IN OCIMENE.

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(*Read before the Royal Society of New South Wales, Dec. 5, 1928.*)

The botany of this new species, Boronia dentigeroides, is fully described by its author, Mr. E. Cheel, in the current issue of the Society's Journal.

It is a tall Rutaceous shrub, varying from 2 to 3 feet in height, with anemone-like leaves and pink flowers, growing abundantly in the Braidwood district of New South Wales.

This plant bears a strong superficial resemblance to the closely allied species Boronia dentigera (Muelleri) and B. anemonifolia (Cunningham), both of which are described botanically in Bentham's "Flora Australiensis," Volume 1, page 321. These two species are widely distributed, grow in elevated sandstone country at not less than 2,000 feet above sea level, are difficult of collection, being upright sparse shrubs, with little foliage. B. dentigeroides, on the other hand, whilst possessing similar foliage, has a more spreading habit, and is in fact a larger plant.

Leaves and terminal branchlets of the new species for investigation of the essential oil were obtained from the Little River, Monga, near Braidwood, growing out of

pockets in basaltic rock. The greatest quantity, however, was secured from the summit of Sugar Loaf Mountain, also at Monga, where it was found growing in fairly luxuriant condition in association with Eriostemon Coxii amidst a rugged quartzite outcrop. (This Journal, Vol. LX. 1926, pages 331-344.) The leaves of the plant are very small and sticky, and on crushing in the hands yield a pleasant characteristic ester odour, which is not readily described.

For purposes of comparison leaves and terminal branchlets of Boronia anemonifolia were collected from a number of mountainous localities in New South Wales, such as Blackheath, Bundanoon and Hill Top.

The oil of Boronia dentigeroides differed from that of B. anemonifolia in the following particulars:—

	B. anemonifolia	*B. dentigeroides*
Yield of oil	0.6 to 1%	1.3 to 2%
Ester No.	54-128	15-34
Pinene	75%	under 30%
Ocimene	trace only	75-80%

The oil of B. anemonifolia is of special interest on account of the high content of ester, but the publication of its chemistry, together with that of B. dentigera, is reserved for a future publication.

The essential oil of B. dentigeroides is of a very remarkable character, as although the leaves are comparatively small, the yield of oil is especially high for such a plant. The occurrence of the olefinic terpene, ocimene in quantity, is particularly noteworthy, although it has been recorded before by the author in papers dealing with the essential oils of Homoranthus. (This Journal, Vol. LVI. 1922, pages 193-201, and Eriostemon myoporoides, Vol. LIX, 1925, pages 206-211.)

BORONIA DENTIGEROIDES (Cheel).

The essential oils varied in colour from almost water white to a pale yellow, were extremely mobile, and possessed a pleasant odour, not easy to describe, but quite characteristic.

Altogether, 453 lbs. weight of leaves and terminal branchlets, cut as for commercial purposes, were subjected to steam distillation, the average yield of oil being 1.5%.

The principal constituents which have so far been identified were found to be ocimene, d-a-pinene, d-limonene (total terpenes, 90%), darwinol, and the corresponding caprate, isovalerianate, and acetate, ethyl formate (?), and isovalerianate, together with small quantities of sesquiterpenes, phenolic bodies, and paraffin, of m.pt. 64-66°.

I wish to direct attention to a distillation of oil made in this Museum on the 26th September, 1898, which is included in the table, under "Experimental." The oil was stored away in a cupboard in the dark, and the chemical and physical constants were not determined until the 30th September, 1920, 22 years later. These results are recorded in the table, as they show no variation from the constants of later distillations which were determined immediately the oil was obtained from the leaves. This is very remarkable, because ocimene is a terpene which readily resinifies, and, moreover, much more stable oils undergo a change in much less time.

Experimental.

Four hundred and fifty-five lbs. weight of leaves and terminal branchlets collected from Monga, New South Wales, yielded, on distillation with steam, crude oils possessing the chemical and physical characters as shown in table, viz. :—

BORONIA DENTIGEROIDES (CHEEL).

Date	Locality	Weight of Leaves.	Yield of Oil.	$d\frac{15}{15}$	α^{20}_{D}	n^{20}_{D}	Solubility in 80% Alcohol. (by weight).	Ester No $1\frac{1}{2}$ hours hot sap.	Ester No after Acetylation	Remarks
26/9/1898	Monga, Braidwood, N.S.W.	lbs. 108	1.3%	0.8438	+16.22°	1.4784	10.0	14.9	33.2	
27/1/1922	do.	4	2.5%	0.8466	+11.7°	1.4778	7.5	28.3	—	Personal collection. Leaves closer cut than usual.
1/4/1922	Little River, Monga, N.S.W.	$90\frac{1}{2}$	1.3%	0.8421	+16.02°	1.4784	8.5	29.0	38 5	
23/4/1924	Sugar Loaf Mountain, Monga, N.S.W.	63	1.4%	0.8455	+10.2°	1.4786	10.0	29.5	54.8	
28/2/1925	do.	104	1.84%	0.8452	+11°	1.4782	9.5	34.2	88.7	
17/8/1927	do.	$85\frac{1}{2}$	1.74%	8.8438	+11.3°	1.4793	10.0	28.2	64.3	

The last named distillation was obtained in 2 fractions. On account of the special interest in the value of examining each fraction separately they are considered worthy of record:—

1st fraction	2 hrs.	1.56%	0.8432	+11.35°	1.4792	10.0	23.2	54.5	
2nd fraction	$1\frac{1}{2}$,,	0.18%	0.8612	+11.20°	1.4802	9.5	64.3	116.2	

The crude oils of every consignment were subjected to fractional distillation, but for the purpose of this paper it will be sufficient to publish those necessary to follow the identification of the various constituents, viz.:—

28th August, 1925. 800 c.c. distilled at 20 mm.

Boiling Point.	Volume.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}	Ester No.
Below 70°	75 c.c.	0.8448	+21.75°	1.4707	20.76
70–75°	192 c.c.	0.8392	+16.4°	1.4749	
75–77°	272 c.c.	0.8336	+ 8.9°	1.4798	
77–80°	80 c.c.	0.8330	+ 4.9°	1.4822	
80–82°	36 c.c.	0.8401	+ 4.25°	1.4826	
82–85°	30 c.c.	0.8411	+ 2.8°	1.4836	
up to 95° (5mm)	25 c.c.	0.8748	+ 3.3°	1.4820	72.74
96–115° (5mm)	36 c.c.	0.9368	+10.1°	1.4760	174.43
Residue	50 c.c.	......	......	......	

17th August, 1927.

400 c.c. of first fraction distilled at 20 mm.

Boiling Point.	Volume.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}
Below 66° ..	16 c.c.	0.8498	+27.55°	1.4698
66–70° ..	81 c.c.	0.8415	+20.4°	1.4744
71–76° ..	166 c.c.	0.8318	+ 9.9°	1.4804
77–80° ..	59 c.c.	0.8301	+ 4.6°	1.4840

Determination of Terpenes.

Fractions Nos. 2, 3 and 4, ex 800 c.c. lot (28/8/'25), were mixed together and redistilled many times over metallic sodium at 774 mm., using a 12 pear column, with the following result, viz.:—

	Boiling Point.	Volume.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}
1	120–140°	1 c.c.	(odour of volatile sulphur compounds)		1.4302
2	140–156°	4 c.c.			1.4521
3	156–160°	37 c.c.	0.8524	+31.7°	1.4677
4	160–166°	38 c.c.	0.8536	+32.05°	1.4702
5	166–175°	48 c.c.	0.8532	+25.5°	1.4770
6	175–180°	53 c.c.	0.8514	+15.2°	1.4939
7	180–185°	23 c.c.	0.8514	+12.4°	1.4990
8	185–187°	36 c.c.	0.8479	+ 8.5°	1.5020
9	187–189°	33 c.c.	0.8388	+ 3.85°	1.5155

d-a-pinene. 32 c.c. of above fraction No. 3 was oxidised with potassium permanganate (see this Journal, 1922, 56, 195), and the crude pinonic acid separated as described in that paper. The acid distilled at 165 at 2 mm., and solidified immediately when placed in the ice chest. The crystals were separated, and on purification from petroleum ether (b.p. 50-60°) melted at 70°; 1.0714 grams in 10 c.c. chloroform gave a reading of +9.625°, $[a]_D^{20^\circ}$ +90°. The semicarbazone melted at 207°.

d-limonene. 4 c.c. of each of fractions Nos. 7, 8 and 9 were separately dissolved in dry ether and amyl alcohol, and treated with bromine at —20°. Small quantities of crystals which separated overnight from fractions Nos. 7 and 9 were pumped off on a Buchner filter funnel, dried and crystallised from ethyl acetate. Typical crystals of limonene tetrabromide were obtained, melting at 104°.

Ocimene. The marked change in boiling point and refractive index of the various fractions distilled at atmospheric pressure confirmed the presence of the olefenic terpene, ocimene, as such behaviour is typical of its conversion into allo-ocimene under the conditions described. It was necessary, however, to utilise fraction No. 4 ex 400 c.c. lot of first fraction (17/8/'27) for experiments to confirm the identity of this interesting and fairly widely distributed terpene, ocimene.

The usual method of reduction by means of sodium and ethyl alcohol proved unsatisfactory. As a matter of fact, the large number of collections of leaves of this species made during the years 1922-1927 was occasioned through my inability to prepare the typical derivative of ocimene, dihydromyrcene tetrabromide. From a study of its chemical and physical constants and general deportment I was quite satisfied that the principal terpene was identical with ocimene, but every year from 1922 to date attempts

were made to obtain the necessary confirmatory evidence, but without success. It was not until early in 1928 that success attended these persistent efforts. The presence of pinene and limonene in association with ocimene undoubtedly mitigated against it.

The best and most successful method for the reduction of ocimene to dihydromyrcene was found to be the electrolytic method, using nickel as a cathode, referred to in paper, by the writer and F. R. Morrison, entitled "Preliminary Note on the Electrolytic Reductions of Piperitone" (this Journal, Vol. LVII. 1923, page 215-217).

The yield of dihydromyrcene was poor, due to lack of precautions for preventing loss of terpene with the gaseous spray from the cathode compartment. The product, however, was of a high degree of purity, as is evident from the following chemical and physical constants, viz.:—

Equal volumes.

Boiling Point.	$d\frac{15^\circ}{15}$	$n_D^{20^\circ}$
68-70° (20 mm.)	0.7883	1.4462 (24°)
70-71° (20 mm.)	0.7957	1.4507 (24°)

Both fractions gave excellent yields of dihydromyrcene tetrabromide, of melting point 88-89°, when examined according to the method described in this Journal (Vol. LVI., 1922, pages 199-200).

Determination of Esters.

Low Boiling Ester.. The first fraction ex 800 c.c. (28/8/'25) was treated with aqueous potassium hydroxide solution in order to decompose the small quantity of ester present. It was not possible to isolate and identify the small quantity of water soluble alcohol, but it appeared to be ethylic alcohol on account of the very definite iodoform reaction. It is well known, of course, that the preparation of this derivative is not conclusive evidence of the presence of this alcohol. The volatile acids were liberated from the

alkaline liquor by means of dilute sulphuric acid and subsequent steam distillation. The qualitative reactions showed the presence of formic and isovaleric acids.

High Boiling Ester. Fraction No. 7, 28/8/'25, Ester No. 174.43, was heated with alcoholic potassium hydroxide solution in order to decompose the ester. The oily layer was separated, washed, dried and heated with phthalic anhydride in benzene solution on the water bath for a prolonged period. The phthalate was separated, and on decomposition with alkali in a current of steam yielded 4 c.c. of a viscous water white alcohol. This liquid possessed the following chemical and physical characters, viz.:—
B.pt., 108-110 (10mm); $d\frac{15^\circ}{15}$ 0.9459 ; $\alpha_D^{20^\circ}$, +30.2° ; $n_D^{20^\circ}$, 1.4890.

It yielded a napthylurethane of melting point 86-87°. The preparation of this derivative is confirmatory of its identity with Darwinol, containing a small quantity of geraniol (see this Journal, Vol. LVII., 1923, pages 238, 244-245).

The slightly lower physical constants were found to be due to a small quantity, under 10%, of geraniol, whose presence could only be established by the detection of citral on oxidation with chromic acid solution.

Acids in combination with Darwinol, etc. The alkaline liquor resulting from the decomposition of the esters was, after evaporation to a small bulk, acidulated with dilute sulphuric acid and subjected to steam distillation. The volatile acids were obtained both as an oil and in aqueous solution, and examined separately. The silver salts were prepared and gave the following results on ignition, viz.:—

Oily acid.

0.3436 gram silver salt gave 0.1604 gram silver—46.67%.

Aqueous acid.

0.5644 gram silver salt gave 0.3257 gram silver—57.52%.

The second portion of original distillate, 17/8/'27, Ester No. 64.27, was similarly treated, and the silver salts obtained therefrom gave the following results on ignition, viz.:—

Oily acid.

0.0382 gram silver salt gave 0.0142 gram silver—37.2%.

The silver salt of capric acid requires 38% silver.

Aqueous acid.

0.5586 gave 0.3234 gram silver—57.89%.

From the above results and the qualitative reactions for the water soluble acids of both isovaleric and acetic acids, the deduction is made that the acids present in combination are identical with capric, isovaleric and acetic acids.

Determination of Sesquiterpenes.

The high boiling fractions, after removal of the alcohols reacting with phthalic anhydride, were found to consist largely of sesquiterpenes, boiling approximately between 120-130° at 10 mm., and possessing the following chemical and physical characters, viz.:—

$d_{15}^{15°}$ 0.9433 to 0.950, $\alpha_D^{20°} + 13°$ to 15°, $n_{D0}^{20°}$ 1.4880.

The quantities were obviously too small for purification, but evidence of the presence of sesquiterpenes was obtained by the well-known colour reactions, with bromine in acetic acid solution and sulphuric acid in acetic anhydride solution.

Determination of Minor Constituents.

The presence of small quantities of phenolic constituents occurring to the extent of about 0.3%, and a paraffin of melting point 64-66°, was determined.

My thanks are due to Mr. E. Cheel, Curator of the National Herbarium, Sydney, for information on the botany of the anemone leaf Boronias, especially B. dentigeroides, and to Mr. F. R. Morrison, F.C.S., A.A.C.I., Assistant Economic Chemist, for much assistance in the chemical investigation of the essential oils.

ON SOME ASPECTS OF DIFFERENTIAL EROSION.

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(With five text-figures.)

(Read before the Royal Society of New South Wales, Dec. 5, 1928.)

Introduction.

Physiographic form is a function of many variables, some mutually related, others entirely independent of each other. Among the more important of these in the case of normal river-erosion are geological structure and the petrographical character of rock-masses, the former including folding, faulting and jointing, the latter comprising mainly chemical composition, mineral constitution and texture. To some extent the factors belonging to either of these groups may act independently of each other, or of those in the other group; folding, faulting and jointing, for example, may affect rocks of widely different petrological characters. On the other hand, there may be physiographic forms due to the co-operation of one or more factors from each group.

The more the writer sees of the physiography of this State the more he is impressed with the very close dependence of physiographic form on the structures, and particularly on the varying composition, of the rock-units; and he is inclined to regard differential erosion as a prime cause of most of the small-scale, as well as of a good many of the larger-scale physiographic features. This view appears to harmonize with the experience of other workers, and helps to emphasize the importance of geological as a sound basis for physiographic study.

It is proposed in this paper to consider differential erosion from two aspects, first as a factor in the evolution of topographic forms resembling those produced by faulting, and secondly in its relation to what may be called antecedent deep weathering.

Fault-Scarps and Erosion-Scarps.

There is a tendency—a very natural one—for the physiographer to assume, as a first hypothesis anyway, that notable and abrupt differences in surface-elevation, especially if the bounding scarp is approximately linear or regular, are due to faulting of such recent date that the country on the upthrow side has not yet been completely dissected. But experience has shown that such physiographic criteria of recent faulting, while admittedly of the greatest value in many cases, require to be used with the greatest caution, and may at times actually be misleading, since physiographic effects very similar to those produced directly by faulting may result from fluvial erosion acting on rock-units of unequal resistance, which are in contact as the result either of normal processes of rock-formation or of faulting during some previous cycle of erosion.

We have in this State examples of fault-scarps, whose existence has been proved. Of such are the Kurrajong fault-scarp, recorded by Professor David(1), and the Mundi-Mundi scarp, in the Barrier Ranges, described by Mr. E. C. Andrews(2); and Professor Griffith Taylor has given good reasons for regarding the ridge forming the western boundary of Lake George as due to a geologically-recent fault(3). But there are also examples of physiography which might be, and in some instances have been, interpreted as the direct result of faulting, on the physiographic evidence alone, but which either are definitely known to be due wholly or mainly to differential erosion, or are best explained on that hypothesis.

Examples of Fault-Line Scarps.

The operation of differential erosion following on faulting to produce what W. M. Davis has called a fault-line scarp[4] is well illustrated along the valley of the Hunter River. For much of its course this valley is bounded on the north and east by hard Carboniferous rocks, while the valley floor is cut mainly out of soft Permo-Carboniferous sediments, and in many places the eastern valley wall is quite steep and scarp-like. As a matter of fact the junction of Carboniferous and Permo-Carboniferous rocks is along a fault-plane (Figs. 1 & 5). A powerful overthrust from the north-east brought the hard rocks up into apposition with

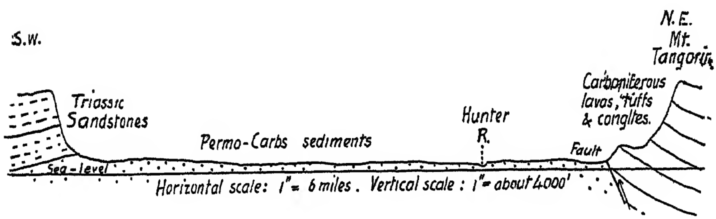

Fig. 1.

Sketch-section across Hunter Valley, with fault-line scarp on one side and erosion-scarp on the other.

the softer ones, this was followed by peneplanation, then by uplift of the peneplain and differential erosion of the softer beds on the downthrust side of the fault. Though the eastward limit of erosion has been set roughly by the fault-plane, the present erosion-slope is thus not a proper fault-scarp at all, but is in the nature of a resequent fault-line scarp. About halfway between Muswellbrook and Scone the fault-plane is crossed by the Hunter River, and the work of G. D. Osborne[5] has shown that about Scone the overthrust is succeeded by a normal fault, which continues northward for a considerable distance, certainly as far as Murrurundi, and possibly much further. The

present writer considered that the scarp existing along the line of this fault might be a revealed fault-scarp[6], one which after its formation had been buried beneath a basalt-flow and had later been revealed by the erosion of the basalt; but while this may be true to a certain extent, erosion has undoubtedly cut down well below the level of the fault-plane as originally exposed, and it is perhaps better to regard the scarp, as it exists to-day, as a resequent fault-line scarp, in part at all events.

The Hunter Valley furnishes at least one other example of a scarp which is in some degree a resequent fault-line scarp. To the west of Cessnock the broad low-lying plain which has been carved by the Hunter and its tributaries is bounded for a space by the inlier of Carboniferous and pre-Carboniferous rocks forming the ridge extending from Mt. Bright to Mt. View, and rising to a height of nearly 1700 feet above sea-level. This ridge is bounded to the east by two normal step-faults, probably of late Permo-Carboniferous age, which have brought Permo-Carboniferous rocks against granodiorite overlain by siliceous Kuttung lavas[7]. On the eastern side river-erosion has removed the later sediments to a very considerable extent, so that the valley is now to all intents bounded, in places with a very abrupt scarp, by the more westerly of the old fault-planes.

Examples of Erosion-Scarps.

But differential erosion may give rise to the appearance of youthful faulting, even when it has not worked along an old fault-plane, and examples of this are numerous in our own State. The broad flat Hunter Valley, already referred to, is bounded on its right or southern bank from Denman for nearly 50 miles by a scarp running about south-east, breached at intervals by tributaries of the Hunter, and their tributaries. A similar scarp runs in a

general N.N.E. direction from the Hunter-Goulburn junction as far as Wingen and beyond, forming the right bank first of the Hunter and then of its meridional tributaries, Dart Brook and Kingdon Ponds. The steep cliffs forming these escarpments rise abruptly from the plain, and give one very strongly, even from a short distance, the impression of being structural in origin, but they are in fact due to sapping of the sub-horizontal hard Triassic sandstones which form them, consequent on the erosion of the softer underlying coal-measure rocks (see Figs. 1 & 5).

The same thing is true of the scarps bounding our coastal plateaux to the north and south of Sydney. Here the steep cliffs are in places quite a considerable distance from the sea-coast, and are fronted by coastal tracts which are very maturely eroded, and even senile in places. Typical country of this kind may be seen to the west from Morrisset, Wyong and other places between Gosford and Newcastle, as well as in the Illawarra district. At first glance the cliffs might easily be taken for fault-scarps—indeed the Illawarra cliffs were so interpreted originally—especially as highland and fronting lowland show much the same degree of dissection, but geological mapping has shown the plateau surfaces to consist of hard, level-bedded and vertically jointed Triassic sandstone, which toward the east has been eroded by sapping of the softer underlying rocks now forming the coastal lowlands.

In all these cases there is a close correlation between rock-resistance, structure and physiography, such as is considered to be a useful criterion in the distinction between fault-line scarps and fault-scarps(8); here, however, it is due entirely to differential erosion, without any co-operation whatever from major differential earth-movements.

So far we have been considering the behaviour of superposed rock-masses of different resistances; but steep slopes, simulating very closely the appearance of fault-scarps, especially in regard to linearity, may occur where the more and less resistant rock-masses are in apposition, with vertical or sub-vertical planes of junction.

According to Mr. E. C. Andrews[9] the New England Tableland is composed of a number of separate plateau areas at different levels, varying from about 2600 to 4800 feet above the sea. These were formerly ascribed to differential elevation of an original peneplain surface, but Mr. Andrews has shown that the lower plateau-levels occur in areas of slates and relatively basic plutonic rocks, while the higher levels consist almost entirely of siliceous rocks, and he considers the present physiographic arrangement to be probably due to differential erosion during a series of cycles.

The sub-meridional valley of the River Murrumbidgee from a little way north of Cooma to its junction with the Cotter in the Federal Capital Territory is bounded on the west by highlands, rising to a maximum elevation of 5000 feet some miles back from the river, whereas the country to the east may be 2500 feet lower. The marked difference in level on the two sides of the river has been attributed to faulting of recent geological age along the course of the river[10, 11], but detailed geological mapping has failed to reveal any such fault, and on the other hand has shown that the high land is composed of a gneissic granite with a contact which is vertical or dips steeply westwards, the invaded rocks being Ordovician (?) schists and slates, and Silurian shales and quartzites (Fig. 2). The boundary between intrusive and invaded rocks runs parallel to and almost along the river bank, and there is at least a strong probability that the physiographic phenomena are due

entirely to differential erosion. The writer hopes to be able to treat this matter of the Upper Murrumbidgee physiography in more detail at a later date.

The sure methods of stratigraphy, as Andrews has called them, and of detailed geological mapping, are probably the best means of detecting the presence of faults, whether indicated physiographically or not, and there is no doubt that the same methods may likewise serve at times to demonstrate the absence of faulting, even where physiography would seem to suggest its presence.

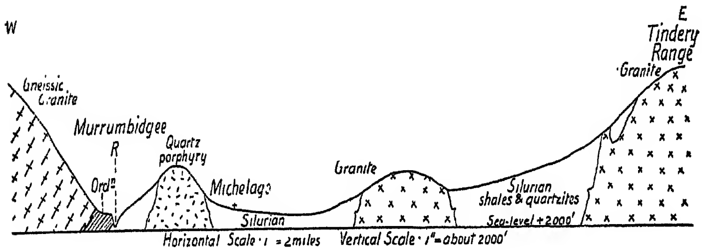

Fig. 2.
Sketch-section across Upper Murrumbidgee Valley at Michelago.

Variability in Physiographic Behaviour of Rock-Masses.

Apart from the effect of recent dislocations, unevenness in topography may be considered as due ultimately mainly to differences in the resistance of rock-masses to mechanical and chemical weathering, as well as to actual river-erosion. In the general case chemical weathering plays a subordinate part in comparison with mechanical, but its importance increases with the decrease of physiographic relief, and in the case of rocks like tuffs, which are often porous, and composed of minerals very susceptible to decomposition, its influence may transcend that of mechanical weathering. Nevertheless it may be assumed that in general the relative rates of erosion of rock-masses are determined not so much

by their decomposability as by their susceptibility to mechanical weathering and erosion.

There are, however, puzzling variations in the behaviour of a given rock from place to place, even in situations where the present-day erosional environments appear to be identical. The changeable behaviour may be quite correctly in each case ascribed to differential erosion, but obviously this process has not operated in the same way in every instance, and some more specific explanation must be sought.

Granite is a rock which, though chemically somewhat weak, has normally a high resistance to mechanical weathering, and hence it might be expected to wear much better than ordinary sedimentary rocks, which are liable to disintegration or decomposition, and which, in any case, owing to the association of weak and strong strata, are generally of very inferior resistance. Even hard siliceous rocks like quartzites and rhyolites, intrinsically strong in virtue of their composition, are often closely jointed and readily fractured by weathering, and might for this reason, and through the weakness of associated rocks, be expected to suffer erosion at a greater rate than granite, which is usually homogeneous to great depths and intersected only by widely-spaced joints.

But while, as is to be expected, we often see granite making the uplands, with rocks of inferior resistance forming the valleys and lowlands, occasionally the reverse is found, granite being at the lower level. And these contrasted effects are displayed whether the associated rocks are older or newer than the granite; in other words the granite may tower over, or may lie at a lower level than, either older or younger rocks, and that, too, quite independently of the relative inherent resistances of the

rocks concerned to mechanical erosion. The topography in which granite forms the uplands may, in the light of what has been said, be regarded as normal, and for that in which granite forms the lowlands many explanations may suggest themselves, as for example the prevalence in the granite of joints or cleavage, the extent of the granite outcrop, and perhaps also the original relative positions, in a vertical sense, of the rock-masses before the commencement of the present cycle of erosion. But there is another factor which, so far as the writer is aware, has not hitherto been stressed in geological writing, and which may, it seems, be of considerable importance in certain cases.

Antecedent Deep Weathering.

It has been stated above that in the erosion of a region chemical weathering plays only a subordinate part, that is, chemical weathering during the currency of the erosion. But the foundations of decay may have been deeply laid in a rock-mass long before the date of its attack by river-erosion. It has been shown by various writers that under conditions of low physiographic relief deep and thorough decomposition of the surface-rocks may be effected. The feeble surface-drainage is unable to cope with the task of removing the products of weathering, while at the same time the proportion of meteoric water that sinks below the surface is high, and this percolating water exerts a solvent action on the rocks, causing their decomposition as far down as the level of the water-table.

The greatest depth to which thorough decomposition may extend is uncertain. Merrill[12] records depths of decomposed rock of the order of 300 and even 400 feet in favourable situations, but this is not necessarily the maximum possible. The decomposing effect of the percolating waters is necessarily selective, inasmuch as some rocks in virtue of inherent characters are more liable to attack than others.

Granite, for example, and basalt, and other igneous rocks except the very siliceous ones, are decomposed much more, and to a much greater depth, than the majority of the sedimentary rocks, which, as Merrill points out, are themselves largely the insoluble residues from decomposition, and therefore no longer subject to chemical weathering.

If now we imagine a region, which has for long been in the last stages of a cycle of erosion, to undergo uplift, so that the peneplain or low-level region of very mature topography and of heterogeneous rock-composition becomes a plateau, the new and the rejuvenated streams will attack the more deeply and thoroughly decomposed rock-masses, and cut down through them with relative rapidity, leaving the less decomposed masses in relief. The differential rate of erosion is thus at first dependent not on the relative resistance of the various rock-units to mechanical weathering and erosion so much as on their differential yielding to antecedent deep weathering, that is, deep chemical weathering during the concluding stages of the immediately preceding cycle of erosion. And it may even be that in the early stages of the new cycle the drainage-pattern may show some of the characteristics of maturity, since the courses of the new streams will have been determined not altogether by slope but in part by the directions of easiest erosion.

If uplift has been considerable, so that the old water-table is a long way above the new base-level of erosion, then it may happen that the rivers will have cut their way through the entire thickness of the decomposed rock before reaching a state of grade. Vertical corrasion will then continue through the fresh rock, but its rate will be very considerably diminished, and, if it happens that the more deeply decomposed rock-mass is really of superior resist-

ance to mechanical weathering and erosion, the tables may gradually be turned, the highlands will be brought low, and the lowlands, through their slower rate of erosion, will in process of time become relatively elevated.

A corollary to the proposition here enunciated is that the water-table level of the readily decomposable rocks during the old cycle of erosion will tend to become the level of temporary formation of broad flat-floored valleys during a comparatively early stage in the new cycle. The water-table is usually taken to be about the downward limit of weathering, below which, in the groundwater region, or belt of cementation, constructive rather than destructive chemical work is carried on. If now we take the case of a chemically weak but mechanically resistant rock like granite, during the uplift following peneplanation it would be rapidly eroded to the lowest level of decay, that is, to its former water-table level. Thereafter erosion of the granite, though not entirely stopped, would proceed with extreme slowness, and a kind of temporary base-level of erosion would be established. The valley would therefore widen and the lowlands extend, until a considerable area had been reduced to approximately the same level, the while the main stream was cutting a notch into the hard granite floor. The process would thus in a way be analogous to that of benching, where the erosion of softer horizontal beds resting on harder produces an approximately uniform surface at the level of the harder strata, and it is conceivable that the appearance of valley-in-valley structure might be produced without any actual interruption in the process of erosion.

The foregoing discussion has centred largely around the behaviour of granite under certain given conditions. This is natural, first because differential erosion in its relation to physiographic relief is studied better in rock-masses

with approximately vertical contacts, as in the case of a bathylith and the invaded rocks, than in those whose boundaries are more nearly horizontal; and secondly because granite is a rock of wide distribution, and possesses the two qualities of chemical weakness and physical resistance. But of course the same principles apply in the case of any rock-masses of contrasted characters.

Illustrative Examples.

Examples of the varying behaviour of granite and other similar rocks are readily found. Perhaps the most common case of all is that in which the granite forms the uplands, while sedimentary rocks form the valleys, and of this many instances might be quoted. A very fine one is illustrated in a section across the country to the east of Michelago, in the Upper Murrumbidgee Valley (Fig. 2). The Tindery Range, up to 5000 feet in height, owes its superior elevation to the granite of which it is made, the lower ground to the west, drained by tributaries of the Murrumbidgee, being composed mainly of Silurian shales, quartzites and tuffs. A smaller intrusion of granite forms a parallel ridge, but at a lower level, a few miles to the west, while nearer the Murrumbidgee the Silurian sedimentary rocks are injected by elongated masses of granite-porphyry, and these form conspicuous ridges where they are widest; in this last case the erosion has been differential as between rock-masses which are both fairly immune from chemical weathering, but of very different degrees of resistance to mechanical weathering and erosion. Further to the west, on the left bank of the Murrumbidgee, gneissic granite, instrusive into Ordovician rocks, causes a further abrupt change in the topography, as explained above.

The inlier of Blair Duguid near Allandale, in the Lower Hunter Valley, illustrates the operation of another factor which makes for differential erosion. Here a mass of

Carboniferous andesite, once an island in the Permo-Carboniferous sea, forms a series of low hills flanked by tuffs and tuffaceous conglomerates of Permo-Carboniferous age, under which, without a doubt, the andesite was formerly completely buried. The area is at present in a state of advanced physiographic maturity.

The andesite, though a fairly easily decomposable rock, is but slowly eroded, while the younger sedimentary rocks are both more easily decomposed and more easily disintegrated. On the whole it appears in this instance that the relatively rapid removal of the tuffs and conglomerates has been due to their greater susceptibility to chemical weathering.

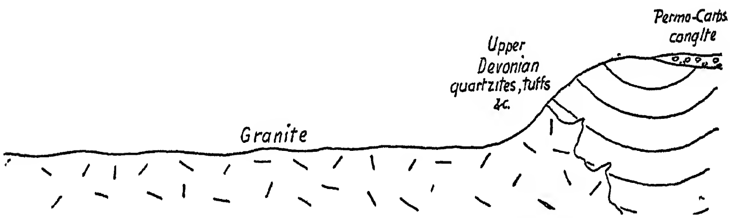

Fig. 3.
Diagrammatic-section at Sodwalls, showing relations between granite and sedimentary rocks.

For examples of the effect of antecedent deep weathering we turn to the western granite areas. The country about Rydal and Sodwalls, about 30 miles on the Sydney side of Bathurst, is composed of granite intrusive into Upper Devonian quartzites, slates, tuffs, &c., locally contact-altered to hornfels; these are overlain by remnants of Permo-Carboniferous conglomerates. The granite in general forms gently undulating, low-lying country, contrasting with the high ground made by the other rocks (Fig. 3). Railway-cuttings and other excavations show decomposed granite to depths of 30 feet and more, this material form-

ing knolls which are clearly remnants of masses once much greater in extent and thickness. This region formed part of the Great Australian Tertiary peneplain, and one can imagine it at that time with a flattish or gently undulating surface cut out of Upper Devonian sediments, granite and Permo-Carboniferous sediments—a set of conditions favourable to differential deep decay of the granite. During one of the minor uplifts which, according to Andrews(13), characterized late Tertiary times, the streams on rejuvenation would rapidly scoop out most of the decomposed granite, forming wide-flung lowlands, leaving the less decomposed sedimentary rocks standing in relief. Later, of course, there was the great Kosciusko uplift which raised the country to its present level of about 3000 feet, but rejuvenation has not yet modified very materially the late Tertiary topography.

The same principle with modifications is illustrated on a smaller scale in the neighbourhood of Hartley, just west of the Blue Mountains. Here the valleys of the Cox and of its tributary, the Lett, have broad flat floors, cut indifferently out of granite, Upper Devonian quartzites, hornfelses and felsite, and Permo-Carboniferous shales, conglomerates and grits; within this mature valley, which is 800 feet below the plateau level, the Cox has entrenched itself to a depth of more than 500 feet (Fig. 4). According to F. A. Craft(14) the present state of affairs was brought about by an uplift, followed by a pause of sufficient duration to enable the river to attain maturity and cut out a wide flat valley, through which it was meandering when further uplift caused it to become entrenched. Now where the entrenched stream is flowing through the hard Devonian rocks it is in a steep-sided youthful gorge, but further up-stream the valley, where it is cut through granite, is markedly less youthful, and in places approaches

maturity. The Devonian rocks, though hard and siliceous and fresh, are much jointed, and break readily into smallish fragments which form talus-slopes, unlike the granite, which is very massive, and jointed only on a large scale; but an examination of the country forming the broad upper valley, where all the rocks are at the same level, reveals in road-cuttings and quarries an appreciable depth of decomposed granite, with occasional masses of fresh rock embedded. An obvious explanation of the physiography of the entrenched valley is that this granite was decomposed to a much greater degree than the associated rocks during the period of stillstand preceding the second

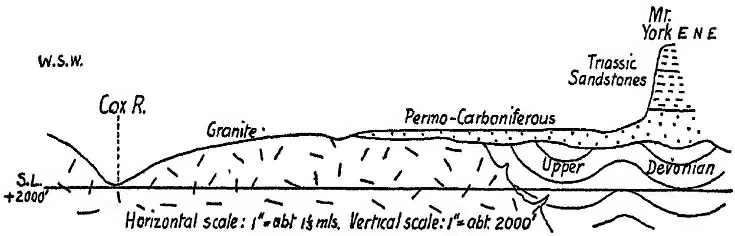

Fig. 4.
Sketch-section across Cox Valley at Hartley.

uplift, when the broad flat valley was an area of low relief and gentle slope, and that since this second uplift the entrenched valley has proceeded with comparative rapidity towards maturity where cut in the soft, decomposed granite.

The writer has not sufficient detailed knowledge of the granite-areas of New South Wales to make possible an extensive examination of the hypothesis (suggested in the first instance by a perusal of Dr. Woolnough's presidential address to this Society(15)) of antecedent deep weathering as set forth above. The hypothesis is, however, put forward in the hope that it may in some instances be found to provide a more precise and satisfying explanation of

anomalous physiographic behaviour in rock-masses, which is now reasonably and correctly, but somewhat vaguely, attributed to differential erosion.

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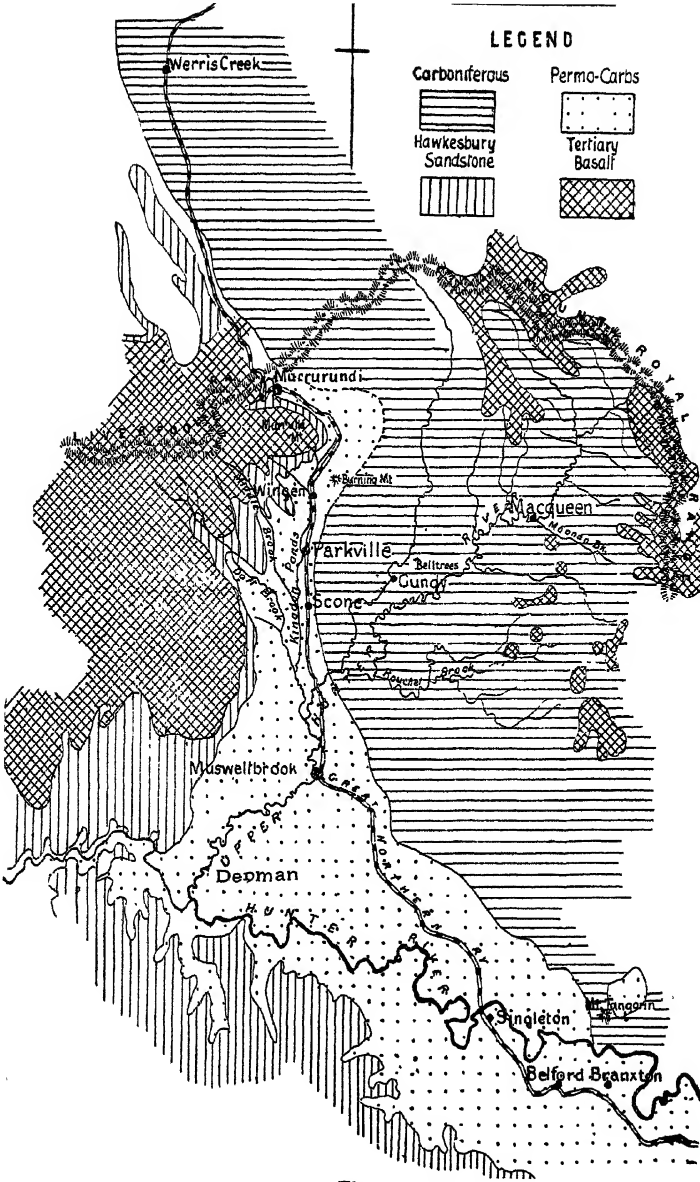

Fig. 5.
Map showing the geology of part of the Hunter Valley.
(Reproduced from this Journal, 58, 1924, Pl. VI.)

FURTHER NOTES ON THE GENUS BORONIA.

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(Read before the Royal Society of New South Wales, Dec. 5, 1928.)

The following notes are a continuation of those already published in the Journal and Proceedings of this Society (42), and are based mainly on specimens contained in the National Herbarium, Sydney, together with a few received from the National Herbarium of Melbourne and the Government Botanist of Queensland.

A brief summary of the species dealt with is as follows:—

Boronia anemonifolia A. Cunn. Discussed in conjunction with the following:—

" *dentigera* F. v. M. Regarded as a variety of *B. anemonifolia* by Bentham, and now rehabilitated to specific rank.

" *dentigeroides*, sp. nov.

" *variabilis* Hook. f. Regarded as a variety of *B. anemonifolia* by Bentham, and now rehabilitated to specific rank.

" *anethifolia* A. Cunn. Regarded as a variety of *B. anemonifolia* by Bentham, and now raised to specific rank.

" *bipinnata* Lindl. Regarded as a synonym of *B. anemonifolia*, var. *anethifolia*, by Bentham, but raised to specific rank.

" *rigens*, sp. nov. Previously included under *B. polygalifolia* as a variety, but regarded as distinct and raised to specific rank.

" *nana* Hook. Included as a synonym under *B. polygalifolia*, var. *trifoliata*, by Bentham, but considered distinct.

" *falcifolia* A. Cunn. Showing a wider geographical range.

" *Gunnii* Hook. Regarded as a variety of *B. pinnata* by Bentham, but considered to be distinct.

" *citriodora* Gunn. Regarded as a variety of *B. pinnata* by Bentham, but considered to be distinct.

Boronia anemonifolia A. Cunn.[13]

Cunningham's original description is in Latin, and may be translated as follows:—

"Leaves petiolate, trifoliate, and leaflets narrow-cuneate, with 2 or 3 teeth on the margins or entire; petioles somewhat channelled. Peduncles one-flowered, solitary in the axils of the leaves. Filaments somewhat glandular, obtuse at the apex, anthers of a chalk-white colour."

The habitat given is "Verge of the Regent's Glen, Blue Mountains." Bentham,[8] gives a compound description and records it for all States except South Australia. It is very doubtful, however, if the Canning River, W.A., plants belong to this species, or to any of its supposed varieties or races as enumerated. Mueller,[34] under *B. polygalifolia*, includes this as a synonym, but, as pointed out by Bentham, [8] it has been subdivided into three, which may be considered as tolerably distinct races, viz.,

(a) *B. dentigera.*
(b) *variabilis.*
(c) *anethifolius.*

My own view is that *B. anemonifolia* A. Cunn., *B. anethifolia* A. Cunn., and *B. variabilis* Hook., are distinct species, and I accordingly suggest the rehabilitation of these three together with *B. bipinnata* of Lindley to specific rank again, as originally proposed by their respective authors. Specimens of typical *B. anemonifolia* are represented in the National Herbarium from the following localities:— Hill Top, Mittagong, Berrima, Yerranderie, Tallong, Barber's Creek, Badgeries Crossing and Mount Wilson.

Boronia dentigera F.v.M.[33]

Mueller's original description of this species is as follows: "Branches nearly terete, spreading, hirtellous; leaves thick, glabrous or pubescent, divaricate, trifoliate; leaflets cuneate-linear, trilobulate at the summit; peduncles

axillary, solitary, one to three-flowered, shorter than the leaves, bearing in the middle a pair of leafy bracteas as well as the subulate-lanceolate sepals slightly hirtellous or pubescent; stamens all fertile with ciliated filaments. Seed asperous."

The habitat given by Mueller is: "On sandhills near the La Trobe River and in McCrae's Island. Also near the Pendland Hills, according to Mr. Dallachi."

Bentham(8) includes this under *B. anemonifolia* as a variety, and cites *Cynanothamnus tridactylites* Bartl. in Pl. Preiss. II, 227, as a synonym. I have not seen the Western Australian plants quoted by Bentham, so cannot say definitely if it really belongs to the present species, but I doubt very much if it is the same species. The Tasmanian specimens collected by C. Stuart and quoted by Bentham(8) and Rodway(43) are *B. variabilis* Hook. Baker(6) and Maiden and Betche(31a) followed Bentham in regarding this as a variety of *B. anemonifolia,* but the structural character of the leaves and hispid sepals, as well as the distinct geographical range, seems to warrant it being regarded as specifically distinct. The whole plant is decidedly more hispid than *B. anemonifolia* and the flowers are different.

Specimens in the National Herbarium, Sydney, are from the following locality: Conjola (W. Heron). In addition to the specimens collected by the late Baron F. von Mueller on the La Trobe River, there are also specimens collected in 1895 by Miss M. Wise from the same locality.

Boronia variabilis Hook. f.(45)
(*B. anemonifolius* var. *variabilis* Benth.(8),
Maid. et Betche.(31a))

The original description of Hooker(45) is in Latin, which may be translated as follows—"Plants erect, glabrous or

pubescent, branches and branchlets more or less studded with warty oil-glands; petioles terete or plain, thick, leaflets oblong or obovate-lanceolate, the tips rather broadly obovate-spathulate, retuse, distinctly nerved and covered with prominent-raised oil-glands; flowers on short or occasionally long pedicels."

There appears to have been a certain amount of confusion concerning this species, as will be seen from the following remarks of Hooker(21)—"The last collection received from Mr. Gunn, so rich in good specimens, enables me to correct my ideas respecting *B. variabilis*, and to refer the varieties α and γ to *B. tetrandra* Lab., notwithstanding the flowers are octandrous. The name *variabilis* will be confined to the var. β, which has the leaves very generally bi-pinnate, the leaflets oblanceolate or cuneate, entire or trifid, marked with evident glandular dots. The branches have two opposite lines of hairs."

Hooker(18) repeats his original description, giving the habitat as "Northern parts of the Island, near the coast; Woolnorth, Hunter's and Flinders' Island in Bass' Straits, Gunn (Fl. Oct.)."

Hooker(18) further states that its distribution is in New South Wales and south-eastern Australia, and gives the following additional description—"A tall, handsome species, 2-4 feet high, exuding copiously a balsamic gum that smells of turpentine and somewhat of Mangos (Gunn). Branches and branchlets usually pubescent and covered with tubercles, each containing an oil-gland, but sometimes smooth. Leaves pinnate; petioles stout, $\frac{1}{2}$-$\frac{3}{4}$ inch long, often flat and dilated, leaflets two or three pairs, more or less obovate-lanceolate to obovate-spathulate, membranous or coriaceous, their apices acute, blunt, rounded, retuse, or in broader leaflets bi-trifid, studded with large glands,

very variable in length and breadth, $\frac{1}{8}$-$\frac{1}{2}$ inch long, generally with an evident prominent midrib. Flowers very numerous, pink, variable in size, similar to those of *B. pilosa*. Narrow-leaved states closely resemble *B. anethifolia* A. Cunn. of New South Wales. The membranous state of this, with spathulate, broad, retuse, or lobed leaflets, looks quite distinct from any of its congeners, but Gunn's suites of specimens show that it passes directly into the following (*B. Gunnii* and *B. citriodora*); it is the *B. dentigera* of Dr. Mueller, and is also found in south-eastern Australia." These latter remarks apply to *B. dentigeroides,* described in this paper, rather than to *B. dentigera* of Mueller.

Hooker, l.c., also gives two varieties, as follows:—

Var. α; foliolis obovatis submembranaceis obtusis retusis 2-3 fidisve (Gunn, 666).

Var. γ; foliolis lanceolatis apices versus latioribus acutis mucronatis acuminatisve (Gunn, 214).

From an examination of the specimens in the National Herbaria, Sydney and Melbourne, I find the following may safely be regarded as distinct and referred to this species—River Mersey (Stuart), labelled *B. polygalifolia* var. *pinnatifolia*, with a footnote in Mueller's handwriting: "This is Hooker's *B. variabilis.*" King Island, ex. Herb. Melbourne, labelled *B. polygalifolia* var. *anemonifolia*; also collected by P. R. H. St. John, in November, 1887, labelled *B. pinnata,* and by Strong ex Herb. Royal Society of Tasmania, labelled *B. polygalifolia,* and by the late Mr. E. Betche as *B. polygalifolia* var. *anemonifolia;* Tasmania, without specific locality (W. H. Archer); Lindisfarne, near Hobart (Rev. H. M. R. Rupp, who remarks: "Grows to 6 feet. Mr. Rodway says it is a form of *B. anemonifolia,* but it is unlike any varieties I have seen in N.S.W.").

Labelled *B. anemonifolia* var. *variabilis* (*B. variabilis* ?) by the late Mr. E. Betche.

Boronia anethifolia A. Cunn.[14]

The original specimens were collected by A. Cunningham in 1825 on the western branches of the Hunter River and Wellington Valley. A description is given in Latin,[14] which may be translated as follows:—"Branches quadrangular; leaves bi-pinnate, glabrous, leaflets linear-lanceolate, entire, the margins more or less revolute and verrucose or rugulose with the raised oil-glands; cymes in the axils of the leaves shorter than the leaves."

Then we have a further description by Lindley[44] in Latin, which may be translated as follows:—"Branches angular, glabrous, resinose-scabrous; leaves bi-pinnate, petiole articulate and winged, leaflets linear, acute, covered with prominent oil-glands; panicles arranged in small corymbs shorter than the leaves; sepals subrotundate. Interior of New Holland, lat. 28½° S., 1827. The flowers are small and closely collected on the short panicles, which are not half the length of even the uppermost leaves."

Bentham[8] unites this with *B. anemonifolia* A. Cunn., as a variety, quoting both the above references, and states that it is "the common form in the interior of Queensland and New South Wales."

From an examination of a fine series of specimens in the National Herbarium, Sydney, I have failed to see the resemblance to *anemonifolius,* as the leaves are more compound, and leaflets narrower and more acute, and thus more closely resemble *B. variabilis*, as stated by Bentham, but in *B. anethifolius* there is no semblance of pubescences or hairs, the whole plant being perfectly glabrous, whereas, in *B. anemonifolius*, *B. variabilis*, *B. dentigera* and *B. bipinnata*, they are all more or less pilose or hispid.

Distribution: N.S.W.—Yerranderie, Warragamba River, Burragorang, Wolgan Valley, Denman, near Merriwa, Mount Danger, near Gungal, Goulburn River, Murrumbo, Quirindi, Howell and Stanthorpe. The latter station is just over the border of N.S.W. in Queensland. Eidsvold, Fraser Island.

Boronia bi-pinnata Lindl.[24]

The original specimens were collected in sub-tropical New Holland by Lieut. Col. Sir T. L. Mitchell in 1846 (No. 387), and described by Lindley[24] as follows—"We here met with a new species of *Boronia*, resembling *B. anethifolia*, of which many varieties afterwards occurred. It grows about 2 feet high, and had solitary pale purple flowers." In a footnote a Latin description is given, which may be translated as follows:—"Glabrous or pilose, leaves bi-pinnate, leaflets linear to sub-terete, flowers sub-solitary, axillary and shorter than the leaves." Bentham[8] included it as a synonym under *B. anemonifolius* var. *anethifolius*. Maiden and Betche[29] recorded it from Stanthorpe, Queensland, as *B. falcifolia*, with the following remarks:—

"These inland specimens are very different-looking from the specimens of the Northern Coast district from the Hastings River to Byron Bay, but cannot be separated even as a variety. In the coast specimens from the Hastings River to Byron Bay the flowers are mostly crowded in the axils of the upper leaves, so as to appear almost terminal, and the leaves are strictly 3-foliate; while the Stanthorpe specimens are more sparsely flowered, the flowers extending down sometimes nearly to the base of the branches, and the leaflets are frequently again tri-foliate, all 3 or the upper ones only. It is an erect shrub, about 2 feet high."

It is quite distinct from both *B. anethifolia* and *B. falcifolia* in that the whole plant is more or less distinctly pilose, whereas both of the above species are quite glabrous. Specimens are represented in the National Herbarium from the following localities:—Bismuth, A. McNutt, July, 1913;

Torrington, J. L. Boorman, October, 1911, and January, 1916; Eidsvold, Dr. T. L. Bancroft; Fraser Island, F. M. Bailey. There are also specimens collected by Dr. Leichhardt without specific locality being mentioned, labelled *B. tetrathecoides,* which really belong to this species.

Boronia rigens Cheel sp. nov.

(*B. polygalifolia* var. *robusta* Bentham and Cheel.[12])

This is described as a variety of *B. polygalifolia* by Bentham,[8] but as the plant has a wide distribution and is so distinct from *polygalifolia,* and rarely found in association with that species. I prefer to regard it as an independent species, and have accordingly proposed the specific name *"rigens"* as Bentham's varietal name *robusta* is inappropriate and somewhat misleading, as the plant is rather stunted in habit, and rarely ever exceeds 1 foot in height.

The original specimens were collected in the Port Jackson district by Sieber (No. 283). It is also recorded by Bentham[8] from the Blue Mountains and Moreton Island.

The following is Bentham's description:—"Leaves 3-foliolate as in the last var. (*trifoliolata,* now *nana*), but stems stout and more shrubby, attaining 2 feet or more."

Distribution:—Sydney district from Randwick to Berowra in the north, to Cataract and Barber's Creek in the south, and Mort's Gully, Lithgow, in the west. There are also specimens from Moreton Bay, Queensland, labelled *B. polygalifolia* var. *ternatifolia* and Medway Rivulet, also as var. *ternatifolia,* collected by Mr. Calvert, from the National Herbarium, Melbourne, which really belong to this species. Specimens have also been sent to me from the National Herbarium, Melbourne, from Mount Abrupt, collected by H. B. Williamson, labelled *B. polygalifolia* var. *trifoliolata,* by the late Baron F. von Mueller, and

from Mount Compass on the Mount Lofty Range, collected by H. Griffith ex Herb. of M. Black. The latter is listed under the name of *B. polygalifolia* in South Australian works and is referred to in my previous paper (this Journal, p. 409) under *B. oppositifolia* from Mount Lofty and Onkaparinga in South Australia. It seems very doubtful if either *B. polygalifolia* or *B. oppositifolia* are to be found in South Australia. It is closely related to *B. hispida*, but may be distinguished by the leaflets being more sub-cylindrical and the sepals being glabrous, whereas those of *B. hispida* are flat and obovate and the whole plant is more hispid.

Boronia nana Hook.(19)

(*B. polygalifolia* var. *trifoliolata* Benth.(8); Maiden and Betche.(31a))

The original specimens of this species were collected by R. C. Gunn (No. 894) "on the top of Rocky Cape, Van Dieman's Land." The description of Hooker(19) is in Latin, which may be translated as follows:—

"Stem short, from which arise numerous glabrous branches. Leaves opposite, shortly petiolate, 3-foliate, the leaflets rather thick, linear-lanceolate, acuminate. Penduncles solitary in the axils of the leaves with a solitary reddish flower, pedicels angular, slightly exceeding the leaves. Sepals 4, same colour as the petals, ovate-acute; petals 4, ovate, obtuse, twice as large as the sepals. Stamens 8; filaments erect or slightly incurved, 4 long alternating with 4 shorter, ciliate. Anthers cordate, ovarium distinctly 4-lobed; style short, pilose."

Hooker adds: "I quite agree with the discoverer of this, Mr. Gunn, in considering it an entirely new species. The tallest of the numerous stems never exceed those now figured, and all the specimens possess the characters here given. It is among the smallest, if not the very smallest, of its kind."

Boronia falcifolia A. Cunn.[44] Mueller.[34a]

The original specimens were collected by A. Cunningham at Moreton Bay. It has since been collected at Wide Bay and Port Macquarie, *vide* Bentham.[8] Specimens in the National Herbarium are also represented from the following localities:—Richmond River, Port Stephens, Evans Head, Byron Bay, Wallis Island and Bulladelah. According to Bentham,[8] it was recorded by Endlicher[14] under the name *B. paleifolia*, through a misreading of Cunningham's label.

Boronia Gunnii Hook. f.[18]

This species was originally regarded by Hooker[45] as *B. tetrandra* var. *grandiflora*, and afterwards as a variety of that species. In 1860 Hooker described it as a distinct species. Mueller[34] included it as a synonym under *B. pinnata*, but Bentham[8] regarded it as a variety of *B. pinnata*.

Although there is a superficial resemblance between this and *B. citriodora*, it is clearly distinct from *B. pinnata*, and cannot be regarded as a variety of that species, which is not found in Tasmania or in Victoria.

From *B. citriodora* it may be distinguished by the leaflets being more crowded and the lowest pair being more distant from the stem, and the distinctive odour being somewhat like that of tansy or rue, as observed by Hooker.

The original specimens were collected at South Esk in Tasmania by R. C. Gunn (No. 8), 17th December, 1844. We have also specimens represented in the National Herbarium collected at Launceston by S. G. Hannaford in 1865, and by W. H. Archer from Tasmania without specific locality being mentioned. A specimen from Launceston, near George's Bay, Tasmania, was collected by A. Simpson (ex Herb. Brisbane) and from Cataract Gorge on basaltic

formation by Rev. H. M. R. Rupp. In Victoria it has been collected at Portland by J. Staer and H. B. Williamson and at Glenelg River by C. Walter, also by C. D. D'Alton without specific locality being mentioned. Bentham also records it from Port Dalrymple, from specimens collected by R. Brown. The latter specimens I have not seen.

Boronia citriodora (Gunn MS.) Hook. f.(18) p. 68.
Lemon Plant.

B. pinnata var. *citriodora* Benth.(8)

The original specimens were collected at Fatigue Hill, 11th February, 1845, by R. C. Gunn (No. 667) and described as a distinct species by Hooker.(18) Mueller(34) regarded it as a variety of *B. pinnata,* and this was followed by Bentham.(8)

Specimens in the National Herbarium, Sydney, are represented from the following localities:—Tasmania, without specific locality, W. H. Archer, labelled *B. pilosa;* Mount East Field, J. H. Maiden, March, 1906, also common around Lake Fenton at alt. 4000 ft.; Mount Roland, near Sheffield, R. H. Cambage (2578), alt. 3800 ft., February, 1911; also T. Carter, A. H. S. Lucas and A. R. Penfold; Pellior, E. D. Briggs, Herb. Morris 1337; Cradle Valley, G. Weindorfer, December, 1914; Plateau and summit of Mount Barrow, County of Dorset, Rev. H. M. R. Rupp (No. 37) with the following note: "Since my last list was made out I have been looking at No. 37 more closely, and it does not seem to correspond with my specimen of *B. Gunnii* from Cataract Gorge. It is more like the form *citriodora*, of which I have a specimen from Cradle Mountain. In the Barrow plant the citron-scent is noticeable, but with it there is also distinctly the sage scent which is so strong in the Gorge *B. Gunnii.*" Plentiful in the neigh-

bourhood of Cradle Mountain, Tasmania, Mr. Thomas Newman, of Monia, *vide* Penfold, Journ. and Proc. Roy. Soc., N.S.W., LIX (1925), 35.

The essential oil, according to Penfold (l.c.) is of a fine rose-like odour, resembling citronellol.

Boronia dentigeroides Cheel sp. nov.

(*B. anemonifolius* var. *dentigera* Maiden and Betche Census (1916) 114; Baker, Proc. Linn. Soc. N.S.W., XXIV (1899) 437, but not of Bentham.)

Fruticulus ad 1-5 ped. alta, similis *B. dentigera* F.v.M., foliis bi-ternatis, foliolis applanatis apice dentatis.

Plants forming slender shrubs from 1 to 5 feet high, similar in general appearance to *B. dentigera* F.v.M., but the leaves are more compound, being twice ternate, and the leaflets more or less flattened and dentate at the apex. Flowers normally in pairs in the axils of the leaves or rarely reduced to a solitary flower as in *B. anemonifolia* and *B. dentigera;* sepals glabrous; petals twice the length of the sepals, creamy-white in the early stage of development, tending to a rich pink colour when fully developed.

Specimens in the National Herbarium, Sydney, are from the following localities:—Braidwood, W. Bauerlen; Clyde Mountain, near Nelligen, J. L. Boorman; Belmore Falls, W. Forsythe; Menangle, Mr. Harper; Timburra (Stuart) ex Herb. Melbourne, labelled *B. polygalifolia* var. *anemonifolia;* Flinders' Island (Gulliver), labelled *B. anemonifolia.*

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ALKALIZATION AND OTHER DEUTERIC PHENOMENA IN THE SADDLEBACK TRACHYBASALT AT PORT KEMBLA.

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(With Plates XXIV, XXV, and two text-figures.)

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Introduction.

In the Geological Survey Memoir dealing with the Southern Coalfield[1] there is an account of the very interesting series of lava-flows and associated tuffs which form such an important part of the Upper Marine Series of the Permo-Carboniferous System along the coast, and appear also in the overlying Bulli Coal-Measures. Mr. G. W. Card, A.R.S.M., has given careful petrographical descriptions of specimens collected from the various flows, and, relying chiefly on peculiarities of chemical composition revealed by analyses, has grouped the whole series broadly with the latites, ranging from normal latites or trachyandesites to olivine-latites or orthoclase-basalts.

The member of the series to which attention is specially devoted in the present paper is that commonly known as the Saddleback dolerite, which outcrops at intervals over a distance of more than twenty miles, from the neighbourhood of Port Kembla south to Broughton Head. Messrs. Jaquet and Harper, who are responsible for the field-work on these rocks, discuss, in the Memoir referred to, the

question as to the exact mode of occurrence of this Saddleback rock, and appear to find difficulty in determining whether it is a flow or a sill, but eventually decide in favour of the former alternative, the point of eruption being placed some distance east of the present coast-line off Port Kembla. The average grainsize of the rock is certainly somewhat coarse for a flow, and there is evidence, to be detailed presently, that parts of the mass are intrusive towards the rest, but the field-occurrences have not been studied in sufficient detail by the present authors to permit of a definite expression of opinion as to the mode of occurrence of the rock-mass as a whole.

Description of the Field-Occurrence in Port Kembla Quarry.

Extensive outcrops of this rock occur at Port Kembla, where it has been quarried for the breakwater and for road-metal. The examination, some years ago, of a thin section of the rock from the Port Kembla Government Quarry prompted one of us (W.R.B.) to visit the place, and the evidences of magmatic alteration of the original rock appeared so convincing that it was decided to investigate and place them on record.

An interesting section is afforded by the north-western wall of the quarry near the end furthest from the entrance, and to the right of one walking towards this distal end; the stone is now being quarried along part of this face, and when the quarry was visited last, in June, 1928, the section, though still available for study, had lost some of the features discernible on the occasion of the original inspection.

The main portion of the face is composed of the normal Saddleback type of rock, with its characteristic black colour, resinous lustre, and abundance of glassy-clear tabular phenocrysts of plagioclase. Towards the south-

west end this passes gradually into a type in which the felspars are greyish-white and somewhat opaque and less lustrous, the groundmass being dull and of a greyish colour, with dark augite phenocrysts showing out on it quite conspicuously. The third type, next encountered, has a dense stony-looking groundmass of blue-black colour, against which semi-opaque greyish-white or pinkish opaque plagioclase phenocrysts stand out strongly, but no augite phenocrysts are visible. In places the groundmass becomes of a chocolate-brown colour, and finally this passes, generally fairly abruptly, into the fourth type, in which the phenocrysts are embedded in a groundmass which is pinkish-green to pink or greyish-pink according to the intensity of alteration; for this pale rock is quite evidently due to the local and irregularly arranged alteration of the third type. The junctions between the two types are not quite sharp, and here and there phenocrysts of felspar may be seen projecting from one type into the other; in places cracks appear to have served as channels for the altering solutions, and the pink rock appears as tongues penetrating into the other. A noteworthy feature of the third and fourth types is the presence of many rounded or irregular vesicles and larger cavities wholly or partially filled with calcite and quartz. All these features are shown in Plate XXV.

The absence of gradation between the second and third types is marked, the rocks being generally distinguishable by differences in texture and colour. Until recently there was a section visible in the quarry-wall which showed a recognizable boundary between the two types, marked in places by an ill-defined band, about an inch wide, along which the rock was largely devoid of phenocrysts, and close to which there was a local tendency to fluxional arrangement of the phenocrysts of the intrusive rock. The impression given in the field, as well as by a study of slides,

is that this third type was injected into the normal rock at a time when the former was still at such a temperature that a certain amount of commingling along the junction was possible.

The relations of the different phases are shown very roughly in the sketch-section (Fig. 1), which is not drawn to scale. From this it will appear that the intrusive type and its alteration-products are confined to the lower part of the quarry-face. From the place where they are first seen, where the intrusion has an upward bulge, they may be traced in a south-westerly direction for about 100 yards to the southern corner of the quarry, and on the southern wall they bulge up again, though they never reach right to the top of the quarry-face.

In a few places the grainsize of the groundmass of the altered normal rock is notably finer than usual at its junction with the intrusion. This is noticeable even in the field, and was rather puzzling at first, seeming to indicate a gradual passage into the intrusive rock, but thin sections showing the actual contact prove it definitely to be an intrusive one; in any case the finer grain is only local, and elsewhere the normal grainsize is maintained right to the contact.

It is of course impossible to tell how far the quarry-floor is above the base of the rock-mass, and what is the downward and lateral extent of the intrusive mass, but we understand that a trial bore put down on the quarry-floor encountered quite a considerable thickness of pink rock.

The entirely irregular incidence of alteration on the normal rock may be noticed in abandoned quarries and other excavations about Port Kembla, but owing to surface-weathering of the outcrops it is hard to determine whether the intrusive type appears as well as the normal rock.

Petrography.

(*a*) *General.*

It is advisable at this point to give some petrographical details of the various rocks concerned. For purposes of convenience they have been divided into two main groups, the normal and the intrusive, and these again have been subdivided according to the varying degrees of alteration into the fresh normal and the altered normal types, and into the dark and light intrusive types, but it must be understood that these subdivisions are made purely for

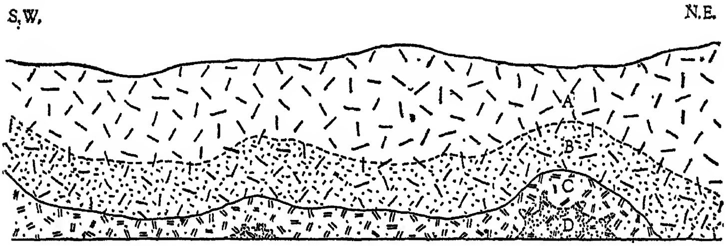

Fig. 1.
Diagrammatic sketch-section along the wall of the Port Kembla Quarry. Length of section about 100 yards, height about 20 feet.
A—Fresh normal rock. C—Dark intrusive.
B—Altered normal rock. D—Pink intrusive.

convenience of reference. The first or fresh normal type is the ordinary Saddleback rock, with very constant petrological characters, while the second represents its local alteration *in situ*; the alteration, however, is by no means constant, but varies in degree from place to place though it is essentially the same in kind. The intrusive rock, though evidently co-magmatic with the normal type, is a separate entity; it is everywhere altered to some extent, and the degree of alteration is expressed by reference to the varying shades of colour, the third type being the dark

or less altered, and the fourth the light or more altered, phase of the intrusive.

(*b*) *The normal rock.*

The first or fresh normal type, as collected in the Port Kembla quarry, conforms well to the general description given by Mr. Card, consisting as it does of porphyritic plagioclase, augite and magnetite, with olivine pseudomorphs, in a somewhat orthophyric groundmass composed essentially of little stout plagioclase prisms, with abundant granules of augite and magnetite, innumerable tiny needles of apatite, and a quantity of interstitial green chlorite sporadically distributed: orthoclase also occurs throughout the rock. The tabular plagioclase phenocrysts, up to about half-an-inch in length and often containing inclusions of groundmass, have a composition about $Ab_{40}An_{60}$, and since the average composition of the felspar, as calculated from the norm, is close to $Ab_{56}An_{44}$ it follows that the plagioclase of the second generation, which like the phenocrysts shows some zoning, must be as acid as andesine.

Orthoclase forms, as Mr. Card has pointed out, untwinned narrow borders or outgrowths to the plagioclase phenocrysts, the outer margin being irregular and dented by the crystals of the groundmass (Plate XXIV., fig. 1), and orthoclase may also be represented by some of the untwinned prisms of the groundmass, besides serving as an investment and interstitial filling round some of the little plagioclase prisms.

The place of olivine is taken largely by green to brownish-green iddingsite, generally associated with a dense green chloritic or serpentinous substance, and with some granular quartz and a little carbonate; no unaltered olivine is visible. Augite is in general so fresh throughout the rock that little green pseudomorphs in the groundmass

are taken to represent olivine of a second generation, though they may represent an original rhombic pyroxene. Of the interstitial materials chlorite is the most abundant, often enclosing apatite needles; orthoclase and a little quartz have also been detected.

The presence of iddingsite in this rock is worthy of remark. As far back as 1923 this mineral was regarded by one of us (W.R.B.) as a product of deuteric alteration of a Permo-Carboniferous basalt from the Maitland district[(2)], and the same mineral has since been recorded as replacing olivine in the Prospect teschenite[(3)], and hypersthene in the Allandale andesite[(4)], in circumstances pointing to deuteric formation, the associated minerals being chlorite, calcite, albite and zeolites. This view as to the deuteric origin of iddingsite is confirmed by the work of Ross and Shannon[(5)], and it may be taken for granted that the presence of this mineral in a rock is a sign of late-magmatic alteration.

Taken by itself, then, this Port Kembla rock would be regarded as one which towards the end of its period of crystallization had suffered deuteric alteration to a certain extent. The formation of orthoclase was probably the penultimate event and the alteration of olivine with interstitial deposition of chlorite and quartz the ultimate event in the consolidation of the rock.

In regard to its classificatory position the rock stands on the border-line between the trachyandesites and the trachybasalts. Mineralogically and texturally it has much in common with the shoshonites, a fact which has been pointed out by Miss Ida A. Brown[(6a)] for the co-magmatic intrusive rocks at Milton.

A number of slides examined for the purpose of studying the alteration of the normal rock show some differences in

texture but have much in common. Progressive alteration is noticed as the intrusion is approached, but the most marked effects are not apparent except in specimens taken within distances of a few feet from the contact. Beyond this contact-zone of most intense alteration there is a good deal of similarity in the phenomena observed, the differences being in degree rather than in kind. In the rocks showing the intermediate stage of alteration augite is fresh and olivine is represented by clear brownish-green iddingsite. The chief interest centres round the alterations of the plagioclase phenocrysts. These, as a result of partial alteration, present a mottled or irregularly chequered appearance, albitization having proceeded along cracks, and being quite irregular in its incidence.

As a matter of fact the determination of the replacing felspar is very difficult: it has an index of refraction distinctly less than that of Canada Balsam, and in places where it cuts across the twin-lamellae of the replaced felspar it is untwinned, so that orthoclase is suspected, especially as it has straight extinction in many cases where the basic felspar is cut normal to (010). However, albite twin-striations have been definitely observed in a number of cases, and the mineral is undoubtedly the soda-felspar. The proportion of albitized material varies in different specimens; it shows a marked though not a steady increase as the intrusion is approached. The surface of the phenocrysts is to a greater or less extent spangled with tiny flakes of sericite, and in some cases with grains of calcite and saussuritic material, but the sericite by far is the most abundant, though the quantity of it varies a great deal in different specimens. The sericite is confined for the most part to the albite areas, and as a rule the albite is to some extent kaolinized (Plate XXIV., figs. 2 and 3).

In the groundmass augite is not so plentiful as in the unaltered rock, and it may disappear altogether, but there is much more chlorite; these circumstances, together with the presence of abundant tiny granules resembling sphene, would indicate that much of the original augite has been altered, though the phenocrysts are still quite fresh, except for an occasional carbonate-filled crack. The felspar of the groundmass is considerably altered; the nature of the alteration cannot always be made out, but albitization and sericitization have been observed, and an occasional feature is the presence of a narrow zone of chlorite between the core and peripheral zone of the felspar crystals. Iddingsite is still the main alteration-product of olivine, but occasionally with some chlorite and a little carbonate and quartz. The iron-ore of the phenocrysts may acquire a rim of leucoxene, proving its titaniferous character.

In specimens taken from near the intrusive contact certain features of the alteration become intensified. There is more albitization of the phenocrysts, and at the immediate contact labradorite has been completely converted into soda-felspar. Sericite is on the whole not abundant, and it may be practically absent, but kaolin may be present. Augite has suffered a marked change, being completely converted into granular carbonates with a little quartz. The iddingsite after olivine has given place largely to a green, pleochroic, uniaxial chlorite with very low negative birefringence; in some cases the two minerals appear together, in others chlorite alone is visible (Plate XXIV., fig. 4).

In the groundmass chlorite is still abundant, but side by side with it there is an increasing proportion of calcite in little patches, doubtless representing pyroxene.

In some places on the quarry-face the altered normal rock is mottled with black rounded spots which are seen

in thin section to be composed of aggregates of green vermicular fibrous chlorite, which ramify into the surrounding rock. The possible significance of these is discussed in another section.

The altered normal rock may become, as noted above, much finer-grained than usual in places; in these fine-grained phases magnetite assumes rod-like forms in the groundmass, and the orthoclase rims to the plagioclase phenocrysts do not appear to be present. These phenomena are doubtless due to local more rapid crystallization than usual.

(c) *The intrusive rock.*

The intrusive rock, while exhibiting within itself certain slight variations, is clearly marked off texturally from the normal types. No unaltered examples of this intrusive rock have been found; in every slide examined every one of the principal original minerals has been completely replaced. The felspar phenocrysts, presumably basic in the first instance, are now of pure albite, and these through slight kaolinization show out grey, opaque white or creamy-white against the blue-black stony groundmass. In thin section these albite phenocrysts are seen to be sharply bounded, showing no trace of an orthoclase border. Some kaolin appears on them, also a little calcite, but sericite is never conspicuous, and may be absent.

The former augite phenocrysts are represented by carbonates, with a little chlorite and quartz, or in some cases by a pale green chlorite which is in process of alteration to carbonate. Olivine crystals have been replaced by iddingsite, and this is now completely pseudomorphed, but with a retention of the original platy structure, by chlorite which in its turn is being encroached on by carbonates. The cracks and boundaries of the original crystals are indicated by haematite (Plate XXIV., figs. 5 and 6).

The groundmass is microporphyritic in felspar, little laths averaging about .15 mm. long being embedded in an exceedingly fine-textured matrix mainly of microlitic felspar and magnetite dust. Of the microphenocrysts some, probably the majority, are certainly albite, but some with Carlsbad twinning and straight extinction may be orthoclase, while the microlites, which in places show a sheaf-like or sub-variolitic arrangement, have a slightly weaker double refraction and are probably in part at least of potash felspar, a conclusion which is likewise reached on chemical grounds, as shown below.

No pyroxene is visible in the groundmass, but scattered little patches of calcite probably take its place. The magnetite dust, while uniformly distributed, is also segregated in little irregular patches associated with carbonates, either clustering about phenocrysts or else surrounding what look like irregular vesicle-fillings of chlorite.

In certain slides of this third type and in some of those cut from the normal rock right at the contact iron ore surrounds, and fills cracks in, the original olivine, and gradually spreads until there are phenocrysts of rather spongy magnetite with the outward form of olivine. These iron ore pseudomorphs, as well as the little segregated masses in the groundmass, would appear to be due to an introduction of iron by magmatic solutions connected with the intrusion.

The dark, or least altered, phase of the intrusive rock grades into a rather chocolate-brown-coloured type, with pink felspar phenocrysts, the change in body-colour being due to oxidation of the iron ore into haematite or a hydrous oxide, which now appears as a pigment right through the body of the rock, except for a few phenocrysts of leucoxenised ilmenite. Chlorite has completely disappeared from the rock, its place being taken by carbonates.

The change from chocolate-brown to a brownish-pink or greenish-pink colour comes for the most part fairly abruptly, and is accompanied by the almost complete disappearance of iron oxide, and by the sudden access of carbonates of iron, magnesia and lime. The albite phenocrysts have survived intact, save for some kaolinization, and some phenocrysts of iron ore still remain. Ferro-magnesian minerals are replaced by aggregates of quartz, carbonates, albite and a little almost colourless chlorite. The groundmass has been encroached upon more and more by the carbonates, till in the extreme case it consists of a mass of carbonates and kaolin with the little micro-phenocrysts of albite embedded in it, and a little limonite, representing all that is left of the iron oxide; in some places carbonate pseudomorphs of felspar microlites may be seen. The extreme alteration of the intrusive has thus been essentially a process of carbonation.

Filled vesicular cavities, either spherical or irregular in shape, are a common feature of the chocolate-brown and pink phases of the intrusive, also irregular drusy cavities, sometimes upwards of six inches in length, in which calcite crystals and quartz prisms up to three-quarters of an inch long have been observed, as well as massive calcite, some of which gives a reaction for iron.

Under the microscope the small cavities in the chocolate-brown rock are seen to contain quartz, albite, siderite, calcite (and probably dolomite), and chlorite, the order of deposition being siderite, albite and quartz, calcite, chlorite. The chlorite is practically colourless, and of low refraction and birefringence. In the pink phase chlorite is negligible, albite in tiny clear twinned prisms is the cavity-lining, and siderite and calcite fill the central parts, the carbonates appearing in places to be invading or replacing the albite. In one slide of the chocolate-brown

rock the cavities contain much of a mineral of moderate refraction, with a pale yellow colour, straight extinction, slight pleochroism, and bright polarisation colours. It is in aggregates of very tiny rosettes, and gives a marked flame-reaction for potassium, so is probably sericite or a sericitic phlogopite. It is bedded on tiny quartz-crystals, and has siderite and calcite as associates.

The mode of formation of these abundant cavities calls for some consideration. It is sufficiently remarkable to find them in an intrusive rock such as this, and an examination of them, both megascopic and microscopic, suggests that they are not ordinary vesicles or steam-holes. They are often highly irregular in shape, though generally curved as to their boundary-walls, and there is a marked absence of orientation of the felspar-microlites of the rock parallel to these boundaries; indeed the microlites even give the impression in places of being cut off abruptly at a cavity. On the other hand the walls of the cavities are smooth, differing in this respect from shrinkage-cavities, into which the ends of crystals often protrude. The impression gained is that these cavities may have been dissolved out of the solidified rock, in much the same way, perhaps, as the "kluften" of the Alpine granites, described by Koenigsberger(7), which are believed to have been formed by magmatic solutions, and afterwards filled with deuteric deposits. There are some indications that in certain cases the cavities may be enlargements of spaces once occupied by olivine or augite, minerals which are susceptible to attack by magmatic solutions.

It seems probable that the chlorite-filled cavities associated with the magnetite segregations in the dark phase of the intrusive may have been formed in this way, likewise the larger, chlorite-filled cavities of the altered normal rock.

Magmatic Relationships of Normal and Intrusive Rocks.

It has been assumed above that the porphyritic albite of the intrusive rock replaces an original basic plagioclase. In the absence of any traces of plagioclase apart from albite in the rock this assumption is incapable of direct proof, but there are certain circumstances which render it exceedingly probable. In the first place the albite phenocrysts and the pseudomorphs after olivine and augite occurring in the dark intrusive are absolutely identical in all respects with those found in the altered normal rock near the contact; it is reasonable to conclude therefore that the original rocks suffered the same alterations, and that the fresh intrusive was mineralogically identical with the fresh normal rock. In the second place a study of the analyses of the two rocks shows their close chemical similarity, except in regard to the relative proportions of soda, potash and lime, suggesting that there has been a rearrangement of these in the intrusive rock, such as would result from albitization. Again it is shown in a later section that the assumption of a molecular replacement of original basic plagioclase by albite would give to the intrusive rock a quantitative mineral composition very close to that of the normal rock.

Although albite has been regarded as capable of primary crystallization from a basic magma[8, 9], it seems justifiable, in view of the circumstances just enumerated, to consider that the normal and intrusive rocks were solidified from the same magma, from which basic plagioclase, augite, olivine and iron ore had crystallized before eruption; and that the differences in texture are probably due to differences in the conditions of crystallization, which caused the orthoclase in the one case to mantle the plagioclase and in the other to form a felt of laths or needles in the groundmass.

Chemical Composition.

In Mr. Card's original study of these South Coast lavas the reliance on chemical analyses of the rocks was emphasised, and chemical data have proved very essential in the present investigation, in the form of four analyses made by one of us (H.P.W.) of selected types, together with three analyses originally made in connexion with Mr. Card's investigation, and quoted from the Southern Coalfield Memoir. These are contained in Table I. The three analyses of the fresh normal Saddleback rock demonstrate the striking uniformity of the chemical composition of the rock over large areas, the slight differences being evidently due in large measure to different degrees of alteration, since in no case has an example of the rock been found perfectly free from deuteric effects.

Mr. Card has pointed out that though the percentage of alkalies, and more particularly of potash, is low for normal latite, the rock has affinities with the latite series, and undoubtedly it should be placed near the basic end of this series, or among the orthoclase-basalts.

There are close chemical resemblances to the shoshonites of Iddings, especially in the unusually low value for magnesia, but the potash is rather lower than in the analysed examples of these types.

The norm of the Port Kembla rock (No. 2) is:

Quartz	4.68
Orthoclase	14.46
Albite	27.77
Anorthite	22.24
Diopside	11.39
Hypersthene	6.52
Magnetite	6.96
Ilmenite	2.28
Apatite	1.34

and the C.I.P.W. classification II. "5. 3. "4. *Andose.*

TABLE I.

	1.	2.	3.	4.	5.	6.	7.	8.
SiO ..	52.86	52.72	52.48	51.06	51.96	51.34	50.75	50.41
Al_2O_3 ..	17.23	16.19	17.32	18.66	15.64	14.78	18.55	14.51
Fe_2O_3 ..	4.10	4.80	4.30	4.15	5.50	1.30	4.13	1.28
FeO ..	4.59	4.14	5.04	4.91	3.51	6.39	4.88	6.27
MgO ..	3.34	4.12	3.65	3.55	2.04	2.75	3.53	2.70
CaO ..	7.62	8.10	7.66	5.64	5.30	3.52	5.61	3.46
Na_2O ..	3.29	3.31	3.43	3.75	5.00	6.49	3.73	6.37
K_2O ..	2.75	2.45	2.53	3.84	3.34	1.35	3.82	1.33
H_2O+ .	1.48	1.56	1.61	2.88	1.51	1.64	2.86	1.61
H_2O- .	0.91	0.92	0.59	0.18	0.57	0.30	0.18	.30
CO_2 ..	0.04	0.07	0.17	0.36	4.22	8.70	0.36	8.54
TiO_2 ..	1.10	1.20	0.74	0.55	1.20	1.10	0.55	1.08
ZrO_2 ..	abs.	abs.	abs.	abs.	—	—	—	—
P_2O_5 ..	0.43	0.48	0.42	0.41	0.44	0.54	0.41	0.53
V_2O_3 ..	0.03	0.02	0.03	trace	trace	—	—	—
SO_3 ..	abs.	abs.	0.09	abs.	—	—	—	—
Cl ..	trace	trace	trace	trace	—	—	—	—
S ..	abs.	abs.	abs.	abs.	—	—	—	—
Cr_2O_3 .	abs.	abs.	trace	abs.	—	—	—	—
NiO ..	trace	trace	abs.	abs.	abs.	—	—	—
CuO ..	—	—	trace	—	abs.	—	—	—
MnO ..	trace	0.07	0.31	0.09	0.13	0.10	0.09	0.10
BaO ..	0.01	0.05	0.06	0.03	trace	—	0.03	—
SrO ..	spec.tr.	spec.tr.		abs.	abs.	—	—	—
Li_2O ..	do.	abs.	abs.	spec.tr.	spec.tr.	—	—	—
	99.78	100.20	100.44	100.06	100.36	100.30	99.48	98.49
Sp.gr. ..	2.575	2.774	2.789	2.758	2.732	2.681		

1. Saddleback Flow, Mullet Creek.
2. Saddleback Flow, Port Kembla Quarry.
3. Saddleback Flow, 3 miles N.W. of Jamberoo.
4. Altered normal rock, much sericitized, Port Kembla Quarry.
5. Dark intrusive rock, Port Kembla Quarry.
6. Pink intrusive rock, Port Kembla Quarry.
7. Analysis No. 4 recalculated for comparison with No. 2.
8. Analysis No. 6 recalculated for comparison with No. 5.

Analyses by H. P. White. Nos. 1, 2 and 3 quoted from Mem. Geol. Surv. N.S.W. Geol. No. 7, p.302.

The appearance of quartz in the norm of a rock containing olivine has been commented on by Mr. Card. It might be accounted for in part by oxidation of some ferrous to ferric oxide, a thing which has apparently taken place; in this case iron which would, if in the ferrous form, use up silica to make femic minerals, is made into magnetite, thus setting free silica for normative quartz. Also there is a little interstitial primary quartz actually present in the rock. But even when all allowances are made there is still an excess of silica, and this is most reasonably explained as due to actual introduction by percolating magmatic solutions.

The specimen of the altered normal type chosen for analysis was one showing a fair degree of albitization and much sericitization. An inspection of this analysis (No. 4) and that of the fresh rock indicates certain changes, but for strict comparison some adjustment has to be made.

It is clear that Merrill's well-known basis of comparison for the analyses of fresh and weathered rocks is not suitable here, since in this method it is necessary to assume that either alumina or iron remains constant, an assumption for which there is no warrant in the present case. Since the volume of the rock apparently remains unchanged, a comparison may be made on the basis of specific gravities, as suggested by Lindgren,[10] and as was done in our paper on the Allandale hypersthene-andesite. The recalculated analysis of the altered normal rock is given in column 7 of Table I, and it indicates, when compared with analysis 2, losses for silica, lime and magnesia, and gains for soda, potash and alumina; iron has remained practically constant. Since the original chemical composition of this altered rock was in all probability closely comparable with that of the fresh normal rock, this increase in alumina must be due to the fact that the loss of alumina involved in the replacement

of labradorite by albite was more than offset by the subsequent formation of sericite, which is richer in alumina than any felspar. Various conjectural equations have been written to explain the formation of sericite from felspar, and in most of these it is assumed that alumina remains constant throughout the process and that the felspar is replaced by sericite and quartz. But consideration will show that where, as here, sericite alone replaces an equal volume of albite, it is necessary to assume not merely a possible substitution of potash for soda, but also an actual addition of alumina, which must have been supplied by the magmatic solutions. Indeed it is hard to see how the sericite which often spangles the plagioclase of igneous rocks could have been produced by weathering, as is sometimes assumed, since ordinary groundwater solutions are not likely to contain the necessary alumina.

The suggestion that the lower silica and higher alumina in the altered normal rock are due to the introduction of sericite into the altered rock receives a certain measure of support from the consideration that the analysis of this heavily sericitized rock is higher in alumina than any of the analyses of the fresh Saddleback rock, and is the highest in this constituent of all the new analyses here presented. And it is, perhaps, more than a coincidence that in the case of the two Allandale rocks the altered rock shows, with increased soda and potash, higher alumina and lower silica than the fresh one. In our Allandale paper no attempt was made to explain these facts, but a re-examination of the micro-slides shows that the importance of the formation of sericite in the altered Allandale rock was not properly appreciated.

The low percentage of CO_2 in the altered normal rock shows the small part played by carbonates in the alteration.

The norm calculated from No. 4 analysis is:

Orthoclase	22.24
Albite	31.44
Anorthite	23.07
Hypersthene	4.92
Olivine	6.37
Magnetite	6.03
Ilmenite	1.06
Apatite	1.01

The classification is therefore II. 5. 3. 3(4). *Shoshonose.*

This is of interest, as showing the ease with which a magmatically-altered igneous rock fits into the C.I.P.W. classification, the sub-rang *Shoshonose* containing 82 analyses in Washington's Tables. The average plagioclase of the rock, according to the norm, has a composition about $Ab_{58}An_{42}$, and, as some of the lime of the normative anorthite is really contained in augite, the actual average composition is more acid than this, as compared with $Ab_{55}An_{45}$ for the felspar of the fresh rock. Further, in the fresh rock normative orthoclase forms a little over 22% of the total felspar, as compared with 29% in the altered rock. These figures serve to emphasise the two most important processes which have contributed to the alteration, namely, albitization, and the addition of potash, largely in the form of sericite, though some must be in orthoclase in isomorphous mixture with the albite.

It is distinctly unfortunate that no specimens of the intrusive rock are to be found free from magmatic alteration. An analysis (No. 5 in Table I) was made of the freshest material available, that with the blue-black groundmass.

The calculation of a norm for this rock would serve no useful purpose, but a calculated partial mineral constitution shows the following weight-percentages:

Orthoclase	19.94%
Albite	41.92
Apatite	1.00
Calcite	8.48
Magnesite	.92

This leaves about 27% for chlorite, iron ores, kaolin, etc. It may be that a small correction is needed for the lime combined as sphene, but there is no warrant given by the microscope for combining any lime as anorthite. The albite phenocrysts are free from sericite, and as they give a strong flame-reaction for potassium this element must be a component of orthoclase in solid solution in the albite; however, there is much more of it present than is capable of existing in this way, so that there must be a good deal of orthoclase present among the microlitic felspar of the groundmass, as was suspected from the microscopical examination.

Of the pink, or most altered, phase of the intrusive a specimen was selected for analysis as free as possible from cavities. Comparing the analysis (No. 6), recalculated on the specific-gravity basis (No. 8), with that of the dark phase of the intrusive, we note a gain of magnesia, soda and carbon dioxide, and a loss of silica, alumina, iron, lime and potash. Here, as before, the gains and losses are to be attributed to the destructional and depositional activities of the magmatic solutions. The carbonates forming a large portion of the groundmass indicate the desilication and carbonation of bases, and some of the carbonates so formed have been deposited, while others have been removed in solution. Some of the silica and calcite have been eventually deposited in the larger cavities, and this probably helps to account for their diminution, and the potash dissolved out would likewise migrate. Iron has changed largely into the ferrous condition as the result of carbonation, and some of it may have migrated. The

loss of iron, however, may be more apparent than real, since it was pointed out that the analysed sample of the dark phase of the intrusive contained much segregated magnetite which may have been introduced during alteration. The gain of soda and carbon dioxide and the loss of potash are probably the most striking effects of the alteration, and these are emphasised in the following mineral constitution, calculated from the analysis:

Quartz	5.40
Orthoclase..	7.78
Albite	55.02
Apatite..	1.34
Ilmenite	1.67
Siderite	9.16
Magnesite..	5.80
Calcite	5.00
Kaolin	6.71
Haematite..	1.28
Rutile	.24
Water	1.01

This list should be reasonably correct, so far as the major items are concerned, but possibly the combinations of iron and of titania should be somewhat modified.

The predominating position of albite shows the stability of this mineral under the conditions prevailing, for the phenocrysts have remained unaltered, and new albite has actually been deposited, not merely in cavities, but along with carbonates in the groundmass and in the olivine and augite pseudomorphs. Flame-reactions show that the albite phenocrysts contain much potash, and the small proportion of orthoclase in the altered rock must be contained almost entirely in solid solution in the albite. The original orthoclase of the groundmass has disappeared, its place being taken by carbonates and albite. The principal processes, then, concerned in this alteration have been albitization, carbonation (involving desilication), and kaolinization

(involving hydration), with solution and removal of potash and other bases.

So far we have compared the normal rock and its alteration products among themselves, and quite separately from the intrusive rock and its variations, but, in view of the probability that normal rock and intrusive were originally of the same chemical composition, the comparison may be extended. For this purpose the analyses of the dark and pink intrusives have been recalculated on a specific-gravity basis, the fresh normal rock being taken as standard, and the results are given in Table II.

To facilitate comprehension the variations are expressed graphically in fig. 2. Probably it would have been better to take as abscissae measured distances along a line on the quarry-face, but as the analysed specimens were not arranged in linear fashion that was not possible, and so specific gravities have been used instead, the diagram thus incidentally emphasising the decrease in density with increase of alteration.

TABLE II.

	A.	B.	C.	D.
SiO_2	52.72	50.75	51.18	49.65
Al_2O_3	16.19	18.55	15.41	14.29
Fe_2O_3	4.80	4.13	5.42	1.26
FeO	4.14	4.88	3.46	6.18
Total Fe as Fe_2O_3 ..	9.60	9.55	9.26	8.13
MgO	4.12	3.53	2.01	2.66
CaO	8.10	5.61	5.22	3.40
Na_2O	3.31	3.73	4.93	6.28
K_2O	2.45	3.82	3.29	1.31
H_2O	2.48	3.04	2.05	1.88
CO_2	.07	.36	4.16	8.41
TiO_2	1.20	.55	1.18	1.06
Sp. gr. ..	2.774	2.758	2.732	2.681

Analyses Nos. 2, 4, 5, and 6 of Table I re-calculated on the basis of specific gravities, the fresh normal rock being taken as the standard of reference.

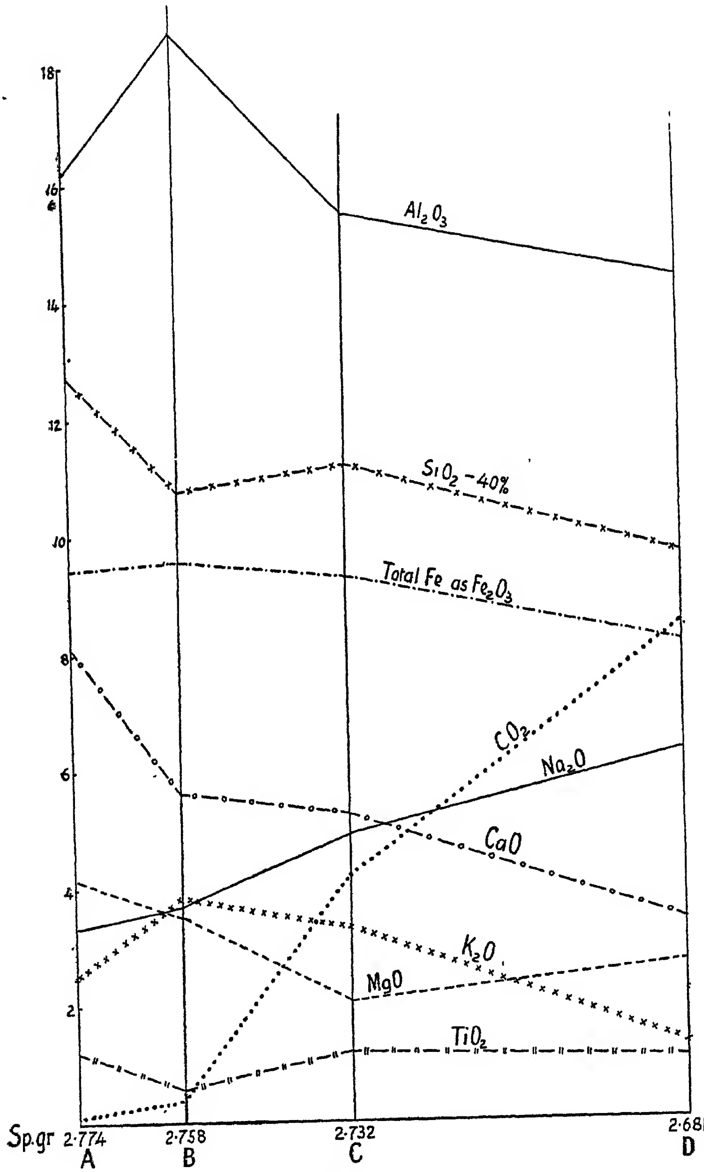
18
16
14
12
10
8
6
4
2
Al_2O_3
SiO_2 -40%
Total Fe as Fe_2O_3
CO_2
Na_2O
CaO
K_2O
MgO
TiO_2
Sp.gr 2·774
A
2·758
B
2·732
C
2·681
D

Fig. 2.

Perhaps the most marked feature of the graph is the rise of carbon dioxide, and to a less extent of soda, towards the most altered end; then there is the general sympathy between alumina and potash, with the sharp rise at first more accentuated in alumina on account of the formation of sericite, and the subsequent decline towards the right, to be correlated with the rise of the carbon dioxide, magnesia and soda curves. The second and last points on the potash and alumina curves are perhaps in some degree complementary, since the orthoclase dissolved out from the light intrusive may in part have been deposited in the altered normal rock as sericite. The very close sympathy between silica and lime is probably not a simple effect, but due to a number of interacting circumstances. The silica-curve is, as is natural, somewhat antipathetic to that for carbon dioxide, but does not decline very sharply, possibly because some of the silica displaced by carbon dioxide has been redeposited as quartz.

Other correlations will suggest themselves.

Further Deductions from the Analyses.

There are a few other interesting and important points which emerge from a detailed consideration of the mineral constitutions derived from the analyses.

The calculated percentages of felspars in the fresh normal rock are:

	By Weight	By Volume
Orthoclase	14.43	15.76
Albite	27.71	29.51
Anorthite	22.20	22.27

For the dark intrusive the corresponding figures are:

Orthoclase	19.87	21.37
Albite	41.77	43.81

These figures of course can only be an approximation to the truth. Now if the reasonable postulates be granted that in the intrusive rock albite replaces, volume for volume, a more basic felspar, and that in the fresh normal rock the orthoclase exists entirely as a separate original mineral, then the following facts are significant:

(1) The total volume-percentage of felspar in the fresh normal rock is 67.54 while the corresponding figure for the intrusive rock is 65.18.

(2) Since we know that the albite of the intrusive rock contains potash, and since Vogt has shown that albite may take up about 12% of orthoclase into solid solution, if to the 41.77% by weight of pure albite in the intrusive rock we add its saturation amount, 5.70%, of orthoclase, the remaining amount of orthoclase, representing that of primary crystallization occurring as microlites in the groundmass, is 14.17, which compares very closely with the 14.43 of original orthoclase in the fresh normal rock.

(3) If we convert the weight-percentages 41.77 and 5.70 into volume-percentages, the volume of plagioclase in the intrusive rock is represented by 49.94, as against 51.78 for the plagioclase of the fresh normal rock.

Further, in the pink intrusive the orthoclase of the groundmass has been almost completely replaced by carbonates, etc.; the orthoclase present in the rock must therefore be contained practically entirely in solid solution in the albite. Now the calculated weight-percentage of albite in the rock is 54.86, and to saturate this 7.48% of orthoclase is required. The actual calculated weight-percentage of orthoclase for the rock is 7.76.

It would appear then that the intrusive rock before magmatic alteration had substantially the same total quantity of felspar and the same proportions of orthoclase

and plagioclase as the normal rock, and that its original plagioclase was replaced by albite containing in solid solution the greatest possible proportion of potash felspar.

Zonal Arrangement of the Alterations.

Series of specimens have been collected along lines more or less normal to the line of contact on the quarry-face between the normal rock and the intrusive, and it has been found possible to establish in a general kind of way zones of alteration. Naturally enough the lines of equal change are by no means concentric with the intrusion, for the quarry-wall gives merely an adventitious section, by no means normal to the very irregular contact, and in any case it is not to be expected that the altering solutions would spread upwards and outwards uniformly; still the degree of change in the normal rock is to some extent a function of distance from the contact.

It has been mentioned above that, even in the freshest typical normal rock as found in the quarry, the olivine is replaced by iddingsite and interstitial chlorite is present; this condition is apparently universal in the Saddleback rock wherever found, and it may be regarded as a regular feature. This qualification being understood then, it has been established that fresh normal rock occurs horizontally and vertically and in intermediate directions away from the intrusion, and, as explained above, the gradual alteration may be plainly traced as one gets closer to the contact with the intrusive rock.

Under the microscope the fresh normal rock is seen to be free from albite, sericite, and carbonates; the augite is fresh, and the olivine is represented by iddingsite; closer in augite remains fresh, but albite and sericite appear fairly rapidly, both showing in a specimen collected only a foot away from the perfectly fresh rock. Still further in,

albite increases, carbonates develop along cracks in the augite, and iddingsite begins to pass over into chlorite.

The following table epitomizes the alterations, the specimens being taken from the zone of altered normal rock in a straight line more or less at right angles to the contact on the quarry-face:

Specimen No.	Distance from contact in ft.	State of Olivine.	State of Augite.	State of Plagioclase.
1	5½	Iddingsite	Fresh; a little carbonate in cracks.	Much albite and sericite.
2	2½	do.	do.	Much albite, but less sericite than in (1).
3	1½	Iddingsite and chlorite.	Entirely carbonated.	do. do.
4	0	Chlorite and a little carbonate.	do.	All albite; very little sericite.

The distance from the contact at which alteration commences in the normal rock varies; traces of alteration have been observed 20 feet away, but on the other hand fresh rock has been collected within 10 feet of the intrusion.

In the intrusive rock the plagioclase is all albite, and sericite is absent or practically so, except for that which was found in the vesicles of one specimen; in the freshest rocks chlorite and carbonates are present, but not much kaolin. In the most altered phases carbonates and kaolin both increase, orthoclase and chlorite practically disappear, and albite becomes more abundant.

Origin of the Solutions.

Much has been written concerning the origin of the albitizing solutions which have affected basic lavas. Some writers have ascribed the alteration to percolating groundwater solutions, while others have looked to sea-water as

the source of the soda introduced into submarine flows. Neither of these sources is possible for the South Coast lavas, inasmuch as:

(1) The alteration is quite irregular in its incidence, and has even proceeded from below upwards;

(2) Much potash has been introduced as well as soda; and

(3) The alterations have occurred in terrestrial as well as in submarine flows.

It is more in accord with the facts to regard the solutions as having been an integral part of the original magma, and the alterations as being deuteric, as has been assumed above.

In the case of the so-called fresh normal rock the alterations that are apparent, such as the iddingsite change and the chlorite deposition, were evidently effected by residual solutions, ejected as part of the magma, and remaining fluid after it had almost completely solidified; the intrusive rock, too, was probably in its turn affected by its own residual solutions. But superimposed on these effects are others of a much more radical character, and these latter, it is believed, are to be attributed to the independent injection of magmatic solutions following the consolidation of normal and intrusive rocks. These solutions were essentially, then, of the nature of post-volcanic emanations, though at Port Kembla they were injected, and may never have reached the surface.

History of the Alterations.

We are now in a position to attempt to sketch the course of events leading to the formation of the Port Kembla rocks as they exist to-day.

The original basic magma must have been poorer in magnesia than the normal basaltic type, but richer in both soda and potash, as well as in the mineralisers, water and carbon dioxide. Physical conditions in the magma were such that the mineralisers were able to segregate or distil off to a very large extent from the rest of the magma, carrying with them much soda and potash; this is virtually equivalent to the separation of the original magma into two partial magmas, the lighter and more fluid one being of course by far the smaller in volume. After partial crystallization of olivine, augite, magnetite and plagioclase, a large-scale eruption of the lower magma took place, forming the normal Saddleback rock; this suffered some alteration from residual solutions before final consolidation. Closely following this came further small eruptions from the same magma through the normal rock, and these cooled with a different texture owing to different conditions, and suffered somewhat from the effect of residual solutions. Partly along the channels followed by the second eruption the upper and very fluid magmatic fraction was now injected. It was probably so fluid that, instead of forcing an intrusive entry, it was able, under pressure, to impregnate the already consolidated rocks, and so its progress was effected not by a process of displacement but rather by metasomatic replacement of its co-magmatic predecessors. It would seem as if there had actually been a further partial segregation or separation in this fluid magma before injection, for the first invading solutions appear to have been relatively poor in carbon dioxide or rich in silica; at all events carbonation was not one of their functions. The most noteworthy change was the replacement of more basic plagioclase by potash-bearing albite; this change was complete in the intrusive, and in the invaded rock at the immediate contact, but decreased in intensity as the solu-

tions spread outwards. The effect of this on the solutions themselves was to diminish their soda and potash and silica content and to enrich them in lime and alumina, and they were enabled to convert the olivine and much of the pyroxene of the groundmass into chlorite. The farthest limit of penetration of these solutions is indicated by the incipient albitization of the plagioclase phenocrysts of the normal rock.

A body of carbonating solution was now forced upwards and outwards, converting nearly everything in the intrusive rock into carbonates and kaolin, and possibly dissolving out irregular cavities wherein was deposited much of their dissolved mineral content: during this period also there was active deposition of albite. Carbonation affected the intrusive rock only in part, its incidence being determined to some extent by the presence of cracks which acted as channels; and the invaded normal rock was affected only within a limited range.

The sequence of events may perhaps be interpreted otherwise, in terms of temperature. The original solutions contained both silica and carbon dioxide, but in the pneumatolytic stage, when temperature was high, the former was the more powerful acid-forming radicle; later, in the hydrothermal stage, when temperature was much lower, carbon dioxide was the more powerful, and displaced silica from combination.

With the exception of soda, potash was carried farthest of all the dissolved material, and it was at the last deposited in great abundance as sericite. This may have crystallized from the first invading solutions after they had been enriched in alumina and depleted in silica, in which case it may have formed simultaneously with the replacing albite with which it is so closely associated. In this connexion

it may be significant that practically no deposition of sericite took place while the solutions were passing through the intrusive rock, and that the heaviest sericitization is found in those altered portions of the normal rock farthest away from the contact. Alternatively the sericite may have been deposited from the later solutions, the potash being in part derived from the orthoclase of the pink intrusive which was destroyed by the carbonating solutions.

The final depositions were those in the cavities and vughs, and these consisted mostly of carbonates, and of quartz, representing the silica displaced from combination by the more powerful carbon dioxide.

Conditions of Eruption.

Mr. L. F. Harper has inferred, principally from the directions of thinning of the lava-sheets, that the main centres of eruption of the South Coast lavas were three, two of which were to the east of the present coast-line, off Port Kembla and off Kiama respectively. With the exception of the topmost, the lava-flows and tuff-beds are interbedded with marine sediments, but there is nothing to tell us definitely whether the principal vents from which they were extruded were terrestrial or submarine. The sediments are of the nature of mudstones, with occasional pebble-bands, and the contained fossils are of shore-living types, so it is evident that shallow-water conditions prevailed.

Attempts have been made to establish genetic relationships between the character of the magma erupted in a region and the nature of the contemporaneous crustal movements, but this is hardly the place to examine in detail these relations for the South Coast lavas. However, it may be noted that the sea-floor was gradually sinking, though not at a rate much exceeding that of the deposition of lava

and ash and mechanical sediment, and that eventually the marine gave place to freshwater conditions without any change in the general character of the erupted rocks.

It is of interest to note that the absarokites and shoshonites and banakites of Yellowstone Park, U.S.A.,[11] with which the South Coast series have very close affinities, were poured out sub-aerially, apparently in connexion with the building up of a Tertiary mountain-range. There is some evidence that these American lavas suffered deuteric alteration,[6a] and it would be interesting to know whether this phenomenon occurred on an extensive scale and whether the results compare at all closely with those described above. It is also perhaps worthy of mention that no examples of pillow-structure have been recorded in any of the South Coast lavas.

Deuteric Alterations in Other Lavas of the Series.

The examination of field-exposures and thin sections of a number of other rocks of the South Coast series makes it clear that magmatic alteration has been very common in them. In the disused quarries as well as in the surface-outcrops of the Saddleback rock about Port Kembla, many evidences of albitization and carbonation may be seen, though none so good as those in the Government Quarry. Specimens of the same flow from Dapto show precisely the features of the altered normal type, and these have likewise been observed near the top of Curry's Hill, Gerringong, where the fresh normal type also appears. As a matter of fact all the flows of the series which occur at Gerringong and on the Curry's Hill section show some alteration. The Cambewarra flow is in places thoroughly albitized and has amygdaloidal phases in which the cavity-fillings are largely chalcedony; below the Saddleback flow, and separated from it by the Jamberoo tuffs, is the Bumbo flow, which here is mostly of a grey or brown instead of a

black colour; it has chloritic pseudomorphs after augite, and albitic replacements of the plagioclase phenocrysts. Underlying this markedly porphyritic phase of the Bumbo flow is a dense, fine-grained phase, not unlike the Cambewarra rock in appearance, which is amygdaloidal, the vesicles being filled with soft, green, chloritic material, between which and the cavity-walls are to be found occasional tiny flakes of metallic copper[6b]; this rock is albitized, and like the chlorite the copper is probably magmatic, either having been held in solution till the deuteric stage was reached, or else dissolved out of the ferro-magnesian minerals and re-deposited.

The Blowhole flow appears to be unaltered for the most part, but at the top it passes into an amygdaloidal phase, which is albitized and has its vesicles filled with radiating natrolite.

Indeed, the perusal of Chapter IV of the Southern Coalfield Memoir makes it clear that deuteric activity has been very widespread through this series of Permo-Carboniferous lavas, for there is scarcely a description of one of the flows, terrestrial or submarine, but contains some reference to the alteration which the minerals have undergone and to the presence of chlorite, calcite, chalcedony and other substances not of primary crystallization.

Zeolites and allied minerals have been reported from a number of the flows; for instance, prehnite and zeolites are mentioned as occurring in the Saddleback flow, and stilbite in the Cambewarra flow. Nevertheless minerals belonging to the group of the zeolites are notably absent from the more massive types of rock, in contrast with other deuterically-altered basic lava-flows which have been examined, and which contain analcite, natrolite and other hydrous silicates filling interstitial spaces between the

felspars, and even replacing the latter partially or completely.

The crystallization-temperatures of the zeolites are probably lower than those of any of the substances found in the Port Kembla rock with the exception of calcite, and as this is present in plenty, the general absence of zeolites in the non-vesicular rocks, either as replacements or as interstitial fillings, would appear to indicate that no material from which zeolites might be made was left in the solutions at the lower temperature at which calcite formed; this may have been because of a lack of water sufficient to permit of deposition of silicates within the temperature-range of the zeolites.

Comparisons with Deuterically-altered Basic Rocks elsewhere.

The alterations described for the Port Kembla rock, and for the South Coast lavas generally, have naturally much in common with those suffered by basic rocks elsewhere. The altered phases differ from typical spilites in many respects,(12) as for example in containing pseudomorphs after olivine and in being relatively rich in potash; nevertheless the presence in both of much albite and of chlorite and carbonates replacing the ferro-magnesian minerals, shows that while the composition of the original magmas differed, and to some extent also the deuteric solutions, yet these latter had sufficient in common, in the way both of composition and in mode of operation, to produce somewhat comparable results.

H. C. Sargent has described from Derbyshire a series of Lower Carboniferous submarine lavas for which he suggests the name potash-spilites.(13) It appears that the relatively unaltered rocks of the series contain iddingsite after olivine, and in some cases may contain original orthoclase, and the alteration of the series has given rise, along

with much that is typically spilitic, to deuteric orthoclase. With Dr. Bemrose's descriptions of the unaltered types(14) no analyses were published, but it would seem that the presence of primary orthoclase links these rocks with the orthoclase-basalts, so that chemically they have something in common with the South Coast lavas. The deuteric solutions affecting the Derbyshire rocks were, however, essentially potash-bearing and devoid of soda, for the analyses quoted by Sargent show an antipathetic relation between the alkalies.

The Permian lavas about Exeter in the same county, described by Teall,(15) are of latitic character, and the presence of iddingsite and carbonates in some of these betokens a certain degree of deuteric alteration. The only one of these basic types analysed contains 7.03% of K_2O, .55% Na_2O and 3.76% CO_2. It would appear, therefore, that deuteric alteration by carbonating solutions rich in potash has occurred.

Very closely comparable with the phenomena appearing in the Port Kembla rocks are some of those described by Bailey and Grabham as occurring in the albitized Carboniferous basic lavas of Arthur's Seat, Edinburgh.(16) In these rocks there are vesicle-fillings and little veins of prismatic albite in association with chlorite and calcite. The albite replacing more basic felspar is invariably spangled with tiny flakes of sericite, and in one instance is accompanied by small veins and patches of anorthoclase. No analyses of these rocks appear to be available for comparative purposes.

Alkalization.

An important part of all deuteric alteration of basic rocks, and acid ones too, is the introduction of alkalies. The examples quoted make it clear that the altering solu-

tions may be rich in soda or potash or both, depending no doubt on the chemical peculiarities of the original magma. Further, the nature of the minerals formed may vary according to circumstances; the soda may appear in albite or in zeolites, and the potash in felspar or in sericite.

Now there are in existence such terms as albitization, analcitization and sericitization to express special results of the introduction of one or other of the alkalies, but it would appear that there is need for another term, of more general significance, that would apply particularly to the case of rocks like those of Arthur's Seat and those of Port Kembla, where both alkalies have been introduced, or where more than one new mineral has been produced. To meet this need the term *alkalization* is proposed. Albitization, sericitization, etc., would then be regarded as special manifestations of alkalization, which itself is one phase or manifestation of deuteric alteration.

Summary.

(1) A microscopical and chemical examination of the Saddleback trachybasalt exposed in the Government Quarry at Port Kembla, and of a co-magmatic rock intrusive into it, indicates that there has been considerable deuteric alteration of both the intrusive and the invaded rocks.

(2) The alterations may be divided into: (a) those produced by residual solutions, consisting mainly of iddingsitization and chlorite-deposition, and (b) those produced by post-volcanic solutions, comprising the formation first of albite and chlorite and later of albite, sericite, rhombohedral carbonates, kaolin and quartz.

(3) The post-volcanic alterations are disposed in roughly concentric zones, the greatest alteration being within the intrusion.

(4) The introduced bases include soda and potash, the former entering into albite and the latter into sericite and into orthoclase isomorphously contained in albite.

(5) It is shown that deuteric alteration is a common feature of the South Coast Permo-Carboniferous lavas, and comparisons are made with other basic rocks elsewhere which show similar alterations.

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Explanation of Plates.

Plate XXIV.

Microphotographs.

Fig. 1.—Fresh normal Saddleback rock. Note plagioclase phenocrysts with orthoclase rim intergrown with the orthophyric groundmass, also small zoned plagioclase phenocryst. Crossed nicols. x 20½.

Fig. 2.—Basic plagioclase phenocrysts of the normal rock, showing partial alteration. The dark, irregular patches across the crystals are of albite at extinction, and the lighter mottlings on it are of sericite. Crossed nicols. x 22¼.

Fig. 3.—Phenocryst of basic plagioclase in normal rock, showing albitization but no sericitization. The lighter patches on it are of albite. Crossed nicols. x 20.

Fig. 4.—Iddingsite pseudomorphs after olivine, in process of alteration to chlorite. The lighter areas near the cracks represent the residual iddingsite, whose cleavage is well shown. The lower dark patch in the photograph is iron ore, the upper a hole in the slide. Crossed nicols. x 22¼.

Fig 5.—The dark phase of the intrusive rock. The albite phenocrysts are clouded with kaolin, and an iddingsite pseudomorph, changed to chlorite sheathed with haematite, may be seen near the middle of the picture. In the microporphyritic groundmass the segregations of magnetite round chlorite-carbonate patches are well shown. Ordinary light. x 19½.

Fig. 6.—A phenocryst in the dark intrusive rock. It was originally of pyroxene, with olivine inclusions. The latter have been altered to iddingsite and then to chlorite, while the host has changed to chlorite. Around and through the phenocryst the chlorite may be seen in process of alteration to carbonates. Ordinary light. x 20.

Plate XXV.

Photograph of a specimen showing junction between the chocolate-brown phase and the pink phase of the intrusive rock. Two tongues of the latter are seen penetrating the former, the channel followed by the altering solutions possibly being represented by cracks which are shown in the photograph. Rounded and irregularly elongated cavities filled with calcite and quartz are to be seen, the biggest coinciding approximately with the position of one of the tongues of pink rock. A number of calcite-filled cavities are faintly discernible in the pink rock. Greatest length of specimen: 6¾ inches.

Fig. 1.

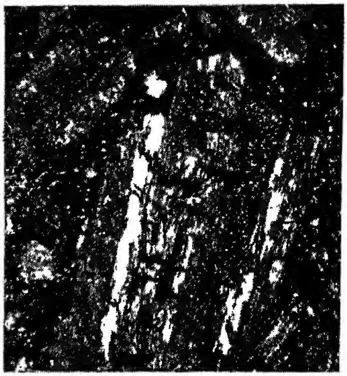


Fig. 2.

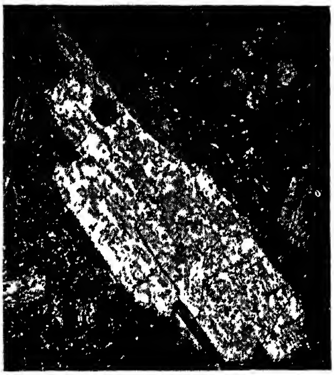
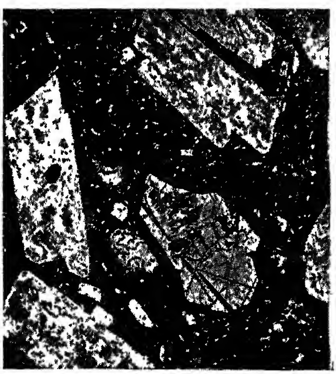
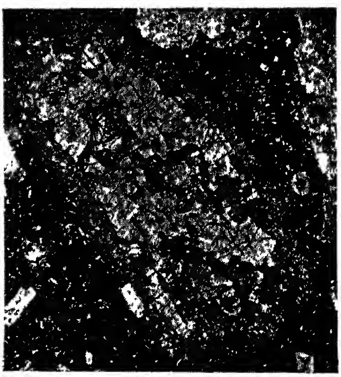
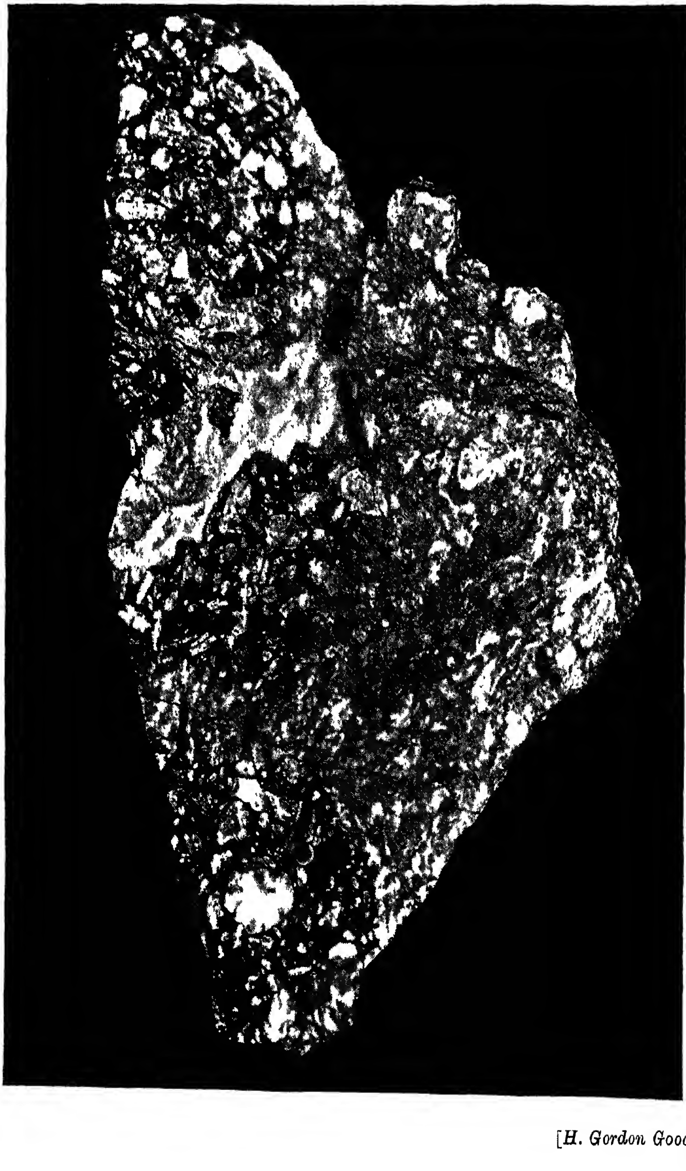


Fig. 3.

Fig. 4.







[*H. Gordon Gooch*

NOTES ON SOME ORGANISMS OF TOMATO PULP.

By G. L. Windred.
(Communicated by Gilbert Wright.)

(Read before the Royal Society of New South Wales, Dec. 5, 1928.)

Introduction.

The manufacture of tomato products is now quite an important business in this State. Whereas, formerly such products were mostly imported from the United States and England now the local production is gradually supplanting such imported goods and with more inquiry into canning and preserving methods there is no reason why we should not be wholly self-supporting in this direction. Indeed, there may be opportunities to export surpluses.

In the manufacture of tomato-pulp, the tomatoes are first thoroughly washed as it has been found that this process gives a better product due to a decrease in mould growth compared with those that are untreated (1). Rotted portions are also cut out and the tomatoes drained of surplus water. The treated tomatoes are then put through a machine which removes the skin, pulps the tomatoes and passes the resulting pulp to a large wooden vat where it is heated by steam pipes. This vat is exposed to the air and is shallow, so that a large proportion of the pulp comes into direct contact with the air. Now, when large quantities of tomatoes are being put through the pulping machine, the pulp only remains in the vat for a short time before it is drawn out with buckets and poured into kerosene cans and sealed. Consequently, the temperature of the pulp in the

vat varies considerably in these rush periods and may not rise high enough to kill off vegetative forms of microörganisms which may be present.

After the pulp is sealed in the bulk cans these are stored for further use. Usually, no provision is made for cooling these stacks of cans and often the temperature of the storage rooms is considerably above normal, so that an opportunity is provided for the growth of microörganisms, either from spores or from vegetative cells, which have escaped being killed in the heating vat. It is during this period of storage that losses due to spoilage occur and these losses are by no means slight. A rough estimate shows from 5 to 15 per cent. spoilage, or even more in warm weather.

For the most part spoilage is manifest by a "sliminess" of the pulp and by the bursting of the cans, the latter being the more important. The object of this investigation has been to find the origin of such spoilage.

Tomato-pulp has a very rich flora of microörganisms including moulds, yeasts and bacteria, all of which, especially the last group, bring about profound changes in the pulp, rendering it, in many cases, unfit for human consumption. Although a good deal of work in this direction has been done in the United States, as yet little has been done here. It has been the aim of the investigator to make counts of the microörganisms occurring in the pulp and also to identify them if possible, especially that organism causing "sliminess."

The material was collected in a sterile aluminium ladle and placed in sterile flasks. Samples were taken of the unheated pulp immediately after it left the pulping machine. Other samples were taken from the heating vat at various levels, from burst cans and from slimy cans. All the samples were subsequently stored at room temperature.

Standard media were used throughout the investigation. Unconcentrated tomato-pulp, heated to 100°C. for one half-hour on three successive days, was used for inoculations.

Quantitative Determinations.

Counts were made both by the dilution method and by a direct method formulated by B. J. Howard (1). In making counts by the dilution method, standard agar medium was used and the plates inoculated at 32°C. for 48 hours. Dilution of 1:10,000, 1:100,000 and 1:1,000,000 were plated, there being six plates to each dilution. Only the plates which showed not more than 200 colonies and not fewer than 50 colonies were counted. The average was taken for each set of dilutions. The following table shows the results of the counts:—

Counts of Microörganisms in Tomato Pulp.

Sample.	Description.	Dilution Method.			Direct Method.		
		Bacteria in Millns. per cc.	Moulds in Millns. per cc.	Yeasts in Millns. per cc.	Bacteria in Millns. per cc.	Moulds % of Fields	Yeasts per 1/60 c.mm.
1*	Unheated Pulp ..	40	16	10	92	65	20
2**	Heated Pulp	4.5	1	0	21	—	—
3	Pulp from good can	6	3	1	77	—	—
4	"Slimy" Pulp	400	130	32	1600	81	154
5	Pulp from burst can	274	23	0	1100	—	—

* From pulping machine.
** From vat.

These counts agree fairly well with those made in the United States although the direct method shows slightly greater numbers. Samples (4) and (5) would be quite unfit for human consumption.

The higher counts by the direct method are probably to be accounted for by the fact that in this method all cells in the field are counted, regardless of whether they are dead or alive, whereas in the dilution method, only the live cells produce colonies.

It will be noticed that there is a striking decrease in numbers in the heated pulp and the 4,500,000 per c.c. probably results, for the most part, from the subsequent germination of the spores. The rise to 6,000,000 in sample (3) may be similarly accounted for or may be due to contact with unsterile surfaces as would be presented by the buckets and the containers. With such numbers of bacteria as occurred in samples (4) and (5) it is only to be expected that profound changes would occur in the pulp, spoiling it for further use.

Qualitative Determinations.

From the plates used in the counting by the dilution method, nine different colonies were selected for identification. Standard agar slopes were made from the colonies and after incubating at 32° C. for 24 hours were replated in order to test purity of the cultures.

A pure culture of each organism having been obtained, the cultural, morphological and biochemical characters of each were studied according to the procedure advised by the Society of American Bacteriologists. The organisms were named according to the scheme set out in Bergey's Manual (2) further corroboration being obtained from the more detailed descriptions in the Journal of Bacteriology (3).

The following organisms were identified:—

1. *Bacillus vulgatus* Flügge.
2. *B. megatherium* De Bary.
3. *B. niger* Migula.
4. *B. graveolens* Gittheil.
5. *B. ellenbachiensis* Stutzer.
6. *B. atterimus* Leh. and New.
7. *B. subtilis* (Ehrenberg) Cohn.
8. *B. mycoides* Flügge.
9. *Aerobacter cloacae.*

It will be noted that none of these are known to be pathogenic, and also, that all except *Aerobacter cloacae* are spore formers and therefore quite capable of withstanding the temperature of the heating vat and so of being able to germinate when the temperature of the pulp falls, which is after the cans have been sealed. It is also significant that all of them produce acid from carbohydrates and as will be seen later this has a bearing on the bursting of the cans. Now since *Aerobacter cloacae* does not produce spores its presence in a sample of heated pulp has to be accounted for. Members of this group have been found in pasteurised milk so that it is capable of withstanding fairly high temperatures. Otherwise it may gain access to the cans by leaks in faulty cans, or may enter before the can is sealed and after it has cooled considerably.

Slime Production.

Pulp which has become slimy has a very characteristic appearance somewhat resembling a thick starch paste but more coherent. When the slimy condition is at its maximum and most viscous, it is not possible to lift it up with a fork or glass rod as it slips off or breaks away. The cohesion is sufficient, however, to allow slime-threads of about 10 c.m. to be drawn out.

An organism was isolated from a sample of slimy pulp and numbered 10. Small portions of the slimy pulp were plated by the usual methods and with the exception of a few colonies of a *mucor* species, which always seems to be associated with the slimy condition, the bacterial colonies were all of the same appearance. Thus the slimy pulp was practically a pure culture of No. 10.

After the isolation of this organism and its transfer to standard agar slopes a test tube full of sterile pulp was inoculated with a heavy dose of organism. The slimy condi-

tion appeared in 72 hours at room temperature (18°C.) After a period of about 17 days the condition began to disappear (of course the duration of the sliminess would depend on many factors such as temperature, mass of pulp, amount of inoculum, etc.). With the gradual disappearance of the slime, a layer of clear amber coloured liquid appeared on the surface of the pulp. At the end of 32 days the sliminess had quite disappeared and the layer of clear liquid occupied about one quarter of the test-tube. The sedimented pulp became much lighter in colour and had a flocculent appearance. There was a very noticeable sour odour following the disappearance of the slime, otherwise the material remained differentiated into clear supernatant fluid and flocculent "precipitate" till the end of the experiment, i.e., for six weeks, without marked change. On plating out some of this material the same colony formation was noticed as at first and on re-inoculating some sterile pulp with this inoculum the slimy condition was again produced. Thus it is highly probable that this organism, No. 10, is the cause of the sliminess. However, since no capsule or envelope could be demonstrated round the organism it is assumed that it is not the organism *itself* which brings about the slimy condition, but rather some *product* of its metabolism.

The following is a brief description of No. 10:—

Morphology.—Long rods with rounded ends, measuring 4μ by $.75\mu$ on an average. Shadow forms common. Arranged singly or in long chains.

Spore-formation. Forms spores early, central in position and sometimes excentric. Cause slight bulge in organism. Average measurement of 1.5μ by $.5\mu$.

Mobility.—Very active in young cultures. Flagella peritrichous and numerous.

Agar Slope.—Moderate growth with a well defined ridge. Tends to spread giving in older cultures a rhizoid appearance. Opaque, raised, smooth, membranous, moist and pure white.

Agar Colonies.—Rapid growth. Different forms, some round and regular, others amoeboid. Surface smooth, moist, glistening, raised, opaque and pure white. A ridge appears near the periphery giving a shallow crater-like appearance.

Gelatine Stab.—Growth best at the top. Line of puncture filiform. Liquefaction infundibuliform. Medium liquefied fairly rapidly.

Broth.—A fragile pellicle formed with slight turbidity near surface. Clears by sedimentation. Long chains.

Potato.—Creamy-white profuse growth, spreading, raised, glistening, very rugose, slimy, membranous consistency. Decided odour.

Glucose Agar.—Rapid growth, filiform but spreading. Flat, dull, rugose, opaque, cream, butyrous.

Gram Stain.—Positive.

Glucose Broth.—Acid, no gas.

Lactose Broth.—Alkaline, no gas.

Sucrose Broth.—Acid, no gas.

Milk.—Rapid casein digestion with clear, amber-coloured fluid in upper part of tube.

Litmus Milk.—Slightly acid in 48 hours with slight coagulation followed by digestion.

Pigment.—None.

This description resembles closely that of *Bacillus ruminatus* Gottheil except that it forms long chains in broth and milk. Also, in agar colonies, no shell-like periphery

was observed as has been attributed to *B. ruminatus*. In all other characters, however, it resembles fairly closely this species and may be a variety of it.

Many cans, both the large kerosene cans and the smaller sizes show a swelling due to increase of internal pressure. At times this pressure increases to such an extent that the can bursts, and in the case of the large bulk cans, with such a force that the whole stack may be thrown down. A large proportion of kerosene-cans of pulp burst, owing, probably, to the fact that they are not so well made as the smaller two-pound tins.

The gas may be produced in two ways: (1) by the action of the *Coli* group of organisms on the carbohydrates of the pulp thus liberating CO_2 and H_2, and (2) by the action of the acid juices on the metal of the container (4).

In the first case when tins of sterile pulp were inoculated with a vigorous culture of *Aerobacter cloacae* and incubated at 37°C. the cans became swollen and burst in 17 days. Since this organism produces both CO_2 and acid in the pulp, the pressure caused by the CO_2 is augmented by the liberation of hydrogen by the action of the acid produced on the metal of the container. This pressure is sufficient to burst open the seams of a two-pound can.

In the second case all the organisms isolated produced acid so that if any great number of organisms remain in the can after processing there is the possibility of them producing enough acid to attack untinned portions of the can and thus liberate hydrogen. The pulp itself shows an acidity of 0.45%, calculated as citric acid, so that together with the products of the bacteria present a considerable acidity may develop, which, if not sufficient to produce enough gas to burst the can, may bulge the ends of the can considerably.

Summary.

Great losses occur due to microbial spoilage of tomato-pulp. Counts of organisms in five samples of tomato-pulp were made including material from burst cans and slimy pulp. Very large numbers of bacteria were present in the last mentioned samples. Ten organisms were isolated from pulp, nine of which are spore-formers, the remaining one being *Aerobacter cloacae.*

An organism which causes sliminess in the pulp resembles *Bacillus ruminatus* Gottheil very closely. Characteristics of the organism are described.

Gas production causing bursting of the cans is due to two causes, (1) the action of acid on the metal of the container, and (2) the production of CO_2 by bacteria.

(Communicated by Gilbert Wright.)

This investigation was carried out in the Faculty of Agriculture, University of Sydney, under the direction of Mr. G. Wright. Acknowledgments are due to Professor R. D. Watt for reviewing the manuscript.

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NOTES ON SOME AUSTRALIAN TIMBERS OF THE MONIMIACEÆ.

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(With Plates XXVI.-XXIX.)

(Read before the Royal Society of New South Wales, Dec. 5, 1928.)

Several Australian genera belonging to the *Monimiaceæ,* a family principally occurring in tropical and subtropical regions, yield useful timbers. Of the eight Australian genera* recorded by Bentham, two are woody climbers, whilst several are too rare to be of commercial importance. The Australian representatives are chiefly confined to the eastern rain forest areas of the mainland, with one genus, *Atherosperma,* occurring in Tasmania.

The following anatomical descriptions apply to specimens of the various woods in the Technological Museum collection.

DORYPHORA SASSAFRAS, Endlicher.

Sassafras, Grey or Black Sassafras.

A medium-sized tree found in the brush forests and on alluvial pockets in gullies, throughout eastern New South Wales and extending into southern Queensland. The wood is very close textured, almost "pine-like," and pale yellowish in colour, becoming darker on exposure. Occasionally dark, irregular streaks are present, especially near the heart, which is occasionally almost jet black. The freshly sawn wood, or even a fresh surface on seasoned wood, usually possesses a pleasant safrol-like

* Bentham, G. Flora Australiensis, Vol. 5, p. 283, 1870.

odour, but this is soon lost on exposure. The wood is not particularly durable, but is apparently immune from attacks by borers, whilst it is said to resist white ants. It works easily, is not fissile, but is inclined to be woolly. The wood is usually without distinctive figure. The weight is moderate, from 30-40 lbs. per cubic foot. Average lateral hardness = 975 lbs.†

Uses.—Available in fairly large quantities and chiefly used for broom handles, brush stocks, stained for cheap furniture, toys, flooring, lining, case material. It is very suitable for automatic turnery. It has also been used for clothes-pegs and tallow cask staves.

Source of material examined: Museum collection; trade supplies.

Macroscopical Characters.—Pores very small, indistinguishable with the naked eye. Soft tissue not apparent. Rays easily visible on end section or on a radial face, somewhat lighter in colour than ground tissue. Growth rings not distinct.

Microscopical Characters. — Pores evenly distributed, usually single or in small groups of 2 or 3, frequently showing partitions due to scalariform bars, occasionally in rows, but more usually separated by very much compressed tracheidal cells; irregularly polygonal or rounded in outline; radial diameter 45-140μ, mean 90μ; tangential diameter 35-110μ, mean 65μ; length of vessel segments, 900-2500μ; walls $2\frac{1}{2}\mu$; end perforation strongly scalariform, bars numerous, up to 100, with correspondingly very tapering segment end; lateral pits few, small-bordered, circular, irregularly arranged, or numerous large, simple, oval or slit-like and scalariform in contact with rays, inter vessel

† Hardness figure is the load required to imbed 0.444" ball to half depth.

pits scalariform bordered; average number per sq. mm. 65; tyloses not observed. Wood fibres very variable in shape and size, thick-walled, often very long, measuring from 1000-2800μ; average diameter 30μ, walls 7-11μ; pit openings slit-like, more or less bordered; transition observed to more copiously pitted tracheidal cells, especially in contact with vessels; frequently septate. Wood parenchyma scanty, diffuse, often appearing as heavily-pitted, septate, prosenchymatous units; usually present in radial rows which correspond to the attenuated ends of the rays, but are not continuous when seen in transverse section. Rays strongly heterogeneous, uniseriate or usually biseriate or triseriate, up to 55μ in width and 2000μ in height, ends tapering to narrow cells corresponding in width to the vertical elements of the wood; thus the normal width of a horizontal ray cell is about 40μ; at the ends of the ray the cells usually become almost square and may become drawn out to a vertical height of as much as 300μ and 20-30μ in width, or two multiseriate portions may be linked with a single row of vertically elongated cells; 3-5 per mm. of transverse section.

Aqueous extract very light brown, very little alteration with ferric chloride, caustic potash, turbid with lead acetate.

When burnt, smoulders to greyish-white ash with small amount of unburnt carbon.

ATHEROSPERMA MOSCHATUM, Labillardiere.

Tasmanian Sassafras.

A large tree, up to 100 feet in height, found in moist gullies principally throughout Tasmania and also in southern and eastern Victoria and in the south-eastern part of New South Wales.

The wood is almost white to light brown in colour, but often with dark streaks or zones near the heart, close-textured, often resembling European Maple or Sycamore, *Acer* sp. It is without odour, although the bark is very aromatic; works easily and cleanly, and is altogether a very useful timber. There is usually no pronounced figure, although on a tangentially cut or "backed-off" surface the variation in density in the growth ring causes a slight "ribbon grain." The wood is tough, not fissile, not durable in exposed positions, and is liable to attack by the Furniture Beetle, *Anobium domesticum.*

Average lateral hardness = 1035 lbs. Weight = 37-41 lbs. per cubic foot.

Uses.—An excellent timber for automatic turnery, *e.g.*, small handles, etc., and is probably the best Australian wood for clothes-pegs. It has been used for interior fittings, cabinet work, brush stocks, light handles, wooden screws, cask staves, wooden buckets, finishing lasts, carving.

Source of material examined: Museum collection; trade supplies.

Macroscopical Characters.—Pores very small, not distinguishable with naked eye. Soft tissue not apparent. Rays fine, evenly distributed, easily visible on end or radial surfaces, appearing somewhat darker than the ground tissue. Growth rings not prominently defined. Sapwood not defined.

Microscopical Characters.—Pores evenly distributed, frequently single or in groups of 2-4 irregularly arranged, not in radial rows, irregularly polygonal in outline; radial diameter 35-85μ, mean, 55μ; tangential diameter 30-55μ, mean 45μ; length of vessel segments 900-1500μ; walls 2-3μ in thickness; end perforation very oblique, strongly scalariform, not always at end of segment, and sometimes extend-

ing for half its length; bars up to 100 in number; lateral pits elongated, elliptical or slit-like, often scalariform, small, circular-bordered and few in number in contact with fibres; tyloses not observed; average number per sq. mm., 155. Wood fibres rather thick-walled, very irregular in size and shape; average diameter 22μ; 900-2000μ in length; wall 5-8μ; pits small, slit-like, borders usually very distinct; very rarely septate. Wood parenchyma scanty, diffuse, chiefly present as non-continuous radial lines corresponding to attenuated ray ends. Rays usually heterogeneous, outer cells often elongated but not so prominently as in *D. sassafras,* at times almost homogeneous, uniseriate to multiseriate, as many as 5 cells in width, maximum width 70μ; up to 1200μ in length but normally not more than 900μ; occasionally ends of rays multiseriate and middle reduced to one cell in width; ray cells frequently with dark granular contents; 4-7 per mm. of transverse section. Growth rings indistinct and due to radial compression of a few rows of wood fibres.

Aqueous extract very pale yellow, often turbid due to starch; usually greenish colouration with ferric chloride; darkened with caustic potash; little alteration to marked turbidity with lead acetate.

Shavings burn to greyish or white ash; smoulders slowly with medium amount of unburnt carbon.

Daphnandra micrantha, Bentham.

Yellow-wood, Satin-wood, Yellow or Grey Sassafras, Yellow Box, Socket-wood, Butter-wood.

A moderate-sized tree found in the coastal brushes of northern New South Wales and extending into Queensland.

The wood is greyish-yellow to yellow in colour, becoming brown on exposure; close-textured, resembling *D. sassafras,* but is usually less aromatic in odour, works more cleanly

and is usually rather harder and heavier. It is tough and non-fissile. Usually no pronounced figure.

Average lateral hardness = 1045 lbs.; weight 28-45 lbs. per cubic foot.

Uses.—Turned articles, small tool handles, door knobs, brush stocks, broom handles, flooring, lining, interior fittings, case material.

Source of material examined: Museum collection; Queensland Forest Service.

Macroscopical Characters.—Pores very small, not distinguishable with the naked eye, but easily seen with pocket magnifier. Soft tissue not apparent. Rays fine, but distinct and easily seen on end or radial surfaces, lighter in colour than ground tissue. Growth rings not prominent, usually seen as fine lines. Sapwood not defined.

Microscopical Characters.—Pores very evenly distributed, frequently single, or in small groups of 2-5, irregularly rounded or polygonal in outline; radial diameter 20-75μ, mean 55μ; tangential diameter 20-65μ, mean 50μ; length of vessel segments 750-1400μ; walls 2-3μ in thickness; end perforations very oblique, scalariform, bars numerous, up to 50; lateral pits elongated, elliptical or slit-like, often scalariform; vessel-fibre pits small, circular, sparsely distributed; tyloses not observed; average number per sq. mm., 100. Wood fibres thick-walled, very irregular in size and shape, average diameter, 30μ; 1200-2100μ in length; walls 7-11μ; pits slit-like, borders small; fibres occasionally septate. Wood parenchyma scanty, diffuse, in thick-walled, heavily-pitted septate prosenchymatous units; principally seen in transverse section as discontinuous radial rows due to ray ends. Rays diffuse, heterogeneous; outer cells elongated but much less than in *D. sassafras* or *A. moschatum;* usually multiseriate, from triseriate up to six

cells in width; diameter up to 110μ; length up to 2.0 mm.; 3-4 per mm. of cross section. Growth rings marked by radial compression of a few rows of wood fibre cells.

Sections cut of the outer part of the wood showed a considerable amount of starch to be present, not only in the rays and longitudinal parenchyma, but also in the thick-walled wood fibres. There seems no doubt but that these cells are used for food storage.

Aqueous extract lemon yellow; very little darkening with ferric chloride or caustic potash; slight turbidity and precipitate with lead acetate.

Shavings burn to greyish or white ash, the amount of smouldering and unburnt carbon varying from large to medium with different samples.

Daphnandra repandula, F. v. Mueller.
Sassafras or Grey Sassafras.

A moderate-sized tree found in the brush forests of northern Queensland.

The wood is yellowish to brownish-yellow in colour, close-textured and resembles *D. micrantha.*

Average lateral hardness = 1075 lbs. Weight about 40 lbs. per cubic foot.

Uses.—Similar to *D. micrantha.*

Source of material examined: Queensland Forest Service.

Macroscopical Characters.—Similar to *D. micrantha.*

Microscopical Characters.—Pores evenly distributed, usually irregularly rounded in shape or occasionally angular; single or in irregular groups of 2-5, often in short radial rows or separated by very compressed fibre tracheids; radial diameter 50-110μ, mean 65μ; tangential diameter 35-90μ, mean 60μ; length of vessel segments 900-

2100μ; walls 2-2½μ; end perforation often extremely oblique, scalariform, bars up to 60; lateral pits scalariform, sometimes oval in contact with ray cells, rounded, small and scattered in contact with mechanical tissue; the vessels are often fusiform and differ little in size and shape from the larger wood fibres (fibre tracheids); tyloses not observed; average number per sq. mm., 90. Wood fibres thick-walled; irregular in size and shape; average diameter 30μ; length 1500-2700μ; walls 5-7μ; pits slit-like, borders very small and at times apparently simple; occasionally septate. Tracheids occasionally present measuring up to 2000μ in length, with numerous small bordered pits. Wood parenchyma scanty, diffuse, septate-prosenchymatous, often seen in transverse sections as discontinuous radial rows due to ray ends. Rays diffuse with tendency to become aggregate; heterogeneous, with considerably elongated end cells much more strongly developed than in *D. micrantha*, the uniseriate portion sometimes extending a greater length than the multiseriate part; usually multiseriate up to 5 cells in width or 75μ; occasionally biseriate; up to 3.0 mm. in length; average number per mm. of cross-section, 4. Growth rings not pronounced, due to radial compression of a few rows of cells.

Aqueous extract pale yellow, similar to *D. micrantha* in behaviour with ferric chloride, caustic potash and lead acetate.

Shavings burn to small greyish ash, medium amount unburnt carbon.

DAPHNANDRA AROMATICA, Bailey.
Sassafras or Grey Sassafras.

A moderate-sized tree found in the brush forests of northern Queensland.

The wood is yellowish-brown in colour, close-textured, and resembles *D. micrantha,* except that the Museum specimens are softer.

Average lateral hardness = 560 lbs. Weight 30-35 lbs. per cubic ft.

Uses.—Similar to *D. micrantha.*

Source of material examined: Queensland Forest Service.

Macroscopical Characters.—Practically similar to *D. micrantha,* but pores rather larger and just visible with naked eye in Museum specimens.

Microscopical Characters.—Pores very evenly distributed, comparatively even in size, irregularly polygonal; usually single, occasionally in small irregular groups, radial diameter 65-150μ, mean 90μ; tangential diameter 55-100μ mean 75μ; length of vessel segments 1200-2000μ; walls 2-3μ; end perforations very oblique, strongly scalariform, bars up to 80; lateral pits, elongated, often scalariform, fibre-vessel pits scattered, circular, bordered; vessels frequently resemble tracheids in size and shape; tyloses not observed; number per sq. mm. 65. Wood fibres moderately thick-walled, irregular in size and shape, average diameter 35μ; length 1000-2600μ; walls 4-6μ; pits usually narrow elliptical with distinct borders, but occasionally border not distinct. Wood parenchyma not abundant, diffuse, appearing in radial rows in transverse section due to elongated ray ends; rays diffuse, heterogeneous, the uniseriate elongated end cells considerably extended; variable in shape, often with multiseriate ends and uniseriate in middle; up to 4 cells or 60μ in width and 1500μ in length; 3-5 per mm. of cross section.

Aqueous extract pale yellow, similar in behaviour to *D. micrantha.*

Shavings smoulder to small greyish ash and large amount of unburnt carbon.

MOLLINEDIA HUEGELIANA, Tulasne.

A small tree, not common in the brushes of eastern New South Wales and Queensland.

The wood is yellow brown in colour, often with irregular dark streaks, close textured, moderately hard, tough and non fissile. It possesses a prominent ray figure when quarter cut.

Average lateral hardness = 1330 lbs. Weight about 45 lbs. per cubic foot.

Uses.—Rarely seen on the market except in mixed brushwoods. Should be suitable for ornamental turnery, small cabinet work and similar purposes.

Source of material examined: Museum collection.

Macroscopical Characters.—Pores indistinguishable with naked eye. Soft tissue not apparent. Rays very prominent on end or radial surfaces. Growth rings scarcely defined. Sapwood not defined.

Microscopical Characters.—Pores evenly distributed, single or in groups of 2-5, sometimes in radial rows; usually irregularly rounded in shape; radial diameter 22-75μ, mean 55μ, tangential diameter 30-75μ, mean 55μ; vessel segments 600-1400μ in length; walls 3-4.5μ; end perforation not so oblique as in *D. sassafras,* scalariform. bars up to 25; lateral pits small rounded or oval, bordered, more crowded than in other species, larger and often scalariform in contact with rays or vessels; tyloses not observed; average number per sq. mm. 55. Wood fibres very thick walled; average diameter 30μ; length 1000-2200μ; walls 5-13μ; pits indistinctly bordered, openings slit-like; septate fibres not seen, but occasionally fibres divided into two distinct cells by a transverse

wall. Wood parenchyma diffuse, in heavily pitted thick walled prosenchymatous units; or seen in transverse section as radial rows corresponding to ray ends. Rays heterogeneous; diffuse with tendency to become aggregate; multiseriate up to 300μ in width and 15mm. in height. Rays per mm. of cross section, 1-3. Growth rings not prominent, indicated by somewhat greater thickening of cell walls.

Aqueous extract very pale yellow; very little darkening with ferric chloride or caustic potash; slight turbidity and precipitate with lead acetate.

Shavings smoulder to brownish or greyish white ash, with medium amount of unburnt carbon.

HEDYCARYA ANGUSTIFOLIA, A. Cunningham.
Wild Mulberry.

A medium-sized to small tree found in creek beds and gullies in Victoria and eastern New South Wales.

The wood is yellow to greyish-brown in colour, close-textured, soft and easily worked, and when of low density inclined to be spongy. Distinct ray figure when quartercut. Average lateral hardness = 495 lbs. Weight 22-30 lbs. per cubic ft.

Uses.—Rarely seen on the market, suitable for small cabinet work.

Source of material examined: Museum collection.

Macroscopical Characters.—Pores practically indistinguishable with naked eye. Soft tissue not apparent. Rays prominent on end or radial surfaces, appearing darker than ground tissue. Sapwood rather paler than heartwood but not sharply defined. Growth rings not prominent.

Microscopical Characters.—Pores fairly evenly distributed, irregularly polygonal in outline, single, or in irregular groups from 2-7, or in short radial rows; radial diameter

35-105μ, mean 75μ; tangential diameter 35-85μ, mean 60μ; vessel segments 500-900μ; walls 2-3μ, end perforation oblique, scalariform, bars up to 20 in number; lateral pits large oval or elongated, often becoming scalariform; vessel-fibre pits small rounded or oval; tyloses not observed; average number per sq. mm. 30. Wood fibres comparatively thin walled, average diameter 30μ; 750-1700μ in length; walls 3-5μ in thickness; occasionally septate; pits small, usually with small borders, occasionally divided into two distinct cells by transverse walls. Wood parenchyma diffuse, or in thick walled septate parenchymatous units, corresponding in size and shape to the fibrous elements; numerous transition stages observed between fibre and parenchymatous cells. Rays heterogeneous, aggregate, oblique sections of vessels or fibres frequently appear isolated in a tangential section of a ray; multiseriate, up to 350μ in width and 3.5 mm. in height; ray volume often very high, especially in specimens of wood with low density; number per mm. of cross section 1-2.

Aqueous extract brownish in colour, brownish or greenish colouration and precipitate with ferric chloride; brown with caustic potash; slight precipitate with lead acetate.

Shavings burn to black residue with little smouldering and no light coloured ash.

The following key is given for the identification of the woods:—

(a) Rays large and prominent on end or radial face.

(b) Rays often exceeding 10 mm. in height = *Mollinedia Huegeliana.*

(b_1) Rays never exceeding 10 mm. in height = *Hedycayra angustifolia.*

(a_1) Rays small not prominent on end or radial face.

(c) Pores very small, numerous, over 125 per sq. mm., wood pale coloured = *Atherosperma moschata.*

(c_1) Pores small, less than 125 per sq. mm. wood yellow.

(d) Rays not exceeding 3 cells in width = *Doryphora sassafras.*

(d_1) Rays often exceeding 3 cells in width. *Daphnandra spp.*

Points of difference between the various species of *Daphnandra* are given under the descriptions for the individual species. There are decided variations in ray widths, pores per sq. mm., and pore size, but insufficient samples were available for examination to state definitely whether these characters are constant.

Summary.

The genera *Doryphora, Atherosperma* and *Daphnandra* belonging to the *Atherospermeæ** furnish close textured "pine-like" timbers usually without any characteristic figure, whilst in the *Momimieæ, Hedycarya, Mollinedia* and *Kibara* possess woods with large prominent rays. Unfortunately, no authentic timber specimens of the last genus were available; the wood is comparatively rare and is not available commercially.

The woods are pale in colour, the whitest being *Atherosperma moschatum. Mollinedia Huegeliana* is the heaviest and hardest of the group. The growth rings are not defined nor is there usually any distinct sapwood. Dark, occasionally almost black, streaks and zones have been observed in *Doryphora, Atherosperma, Daphnandra* and *Mollinedia.* The cell walls become dark yellow-brown in colour and the

*Bentham and Hooker, genera Plantarum, vol. 3, p. 139, 1883.

rays and parenchymatous cells filled with a dark substance. The cause of the stain is apparently fungal.

The vessels are in all cases evenly distributed, with decidedly scalariform end perforation, and show extreme elongation, the segments reaching a length of 2½ mm. in *D. sassafras.* The inter-vessel pits are typically scalariform and bordered. The smaller vessel-fibre pits are usually few and scanty in the *Atherospermeæ.* The maximum average pore number of 155 per unit area occurs in *Atherosperma moschata* and the minimum of 30, in *Hedycarya angustifolia.* Tyloses were not observed.

Typical tracheids are rarely present, the mechanical tissue consisting principally of wood fibres (fibre tracheids), usually with very thick walls and more or less developed bordered pits. Solereder* states that the prosenchymatous ground-work of the wood bears simple pits in *Hedycarya* and *Daphnandra,* indistinctly bordered pits in *Mollinedia* and typical bordered pits in *Atherosperma* and *Doryphora.* In the material examined bordered pits undoubtedly occur in the fibre tracheids of *Daphnandra,* but the borders are less distinct in *Hedycarya.* The degree of development of the border varies considerably in the one species and this feature does not seem to possess any very important diagnostic value. Septate wood fibres were found in all genera except *Mollinedia.* Septate wood fibres with simple pits, recorded by Solereder (l.c.) as occurring in all species, were not found, although prosenchymatous, septate, thick walled, simply pitted wood parenchymatous elements are present; these undoubtedly show close affinity between the wood parenchyma and the fibre cells. Further in *Daphnandra micrantha,* a considerable number of the thick walled fibre

* Solereder, Systematic Anatomy of the Dicotyledons. English Translation, Vol. 2, p. 701, 1908.

cells contained numerous starch granules; although food storage is supposed to be the function of living cells, there was nothing to distinguish these cells from the typical wood fibres. The fibres reach a considerable length in some species e.g. 2,800μ in *Doryphora sassafras* and over 2½ mm. in *Daphnandra repandula* and *D. aromatica*.

The wood parenchyma is usually rather sparsely distributed, but due to the considerable elongation and attenuation of the ends of the medullary rays, the outer cells correspond in shape and size with the normal vertical parenchyma, and thus bring the rays into very intimate contact with the other elements of the wood.

The rays are heterogeneous, with the end attenuation especially developed in *Daphnandra aromatica* and *Doryphora sassafras* and least in *Mollinedia Huegeliana.* In *Mollinedia* and *Hedycarya* the rays reach their maximum width of about 300μ, whilst in the other genera examined rarely exceed 100μ. The maximum height of 15.0 mm. is found in *Mollinedia.* The rays do not appear to be more than triseriate in *Doryphora* and *Atherosperma*, but occasionally attain a width of six cells in *Daphnandra*.

In conclusion I wish to acknowledge the help given by Messrs. D. Cannon and F. B. Shambler of the Museum Staff in the preparation of the specimens.

EXPLANATION OF PLATE.

Fig.1.—Doryphora sassafras. Transverse section of wood showing even pore distribution; the transverse septa seen in many of the vessels are due to the scalariform bars. The wood fibres are very thick walled. The vessels are frequently only separated by considerably compressed fibre cells. × 37.

Fig. 2.—Atherosperma moschatum. Transverse section of wood showing even distribution of very small pores. The discontinuous nature of the radial rows of vertically elongated parenchyma due to the attenuated ray ends is clearly indicated. × 37.

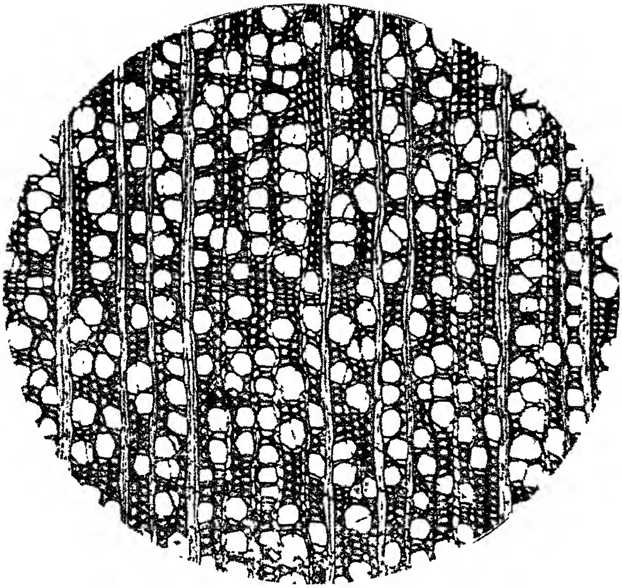


Fig 1.

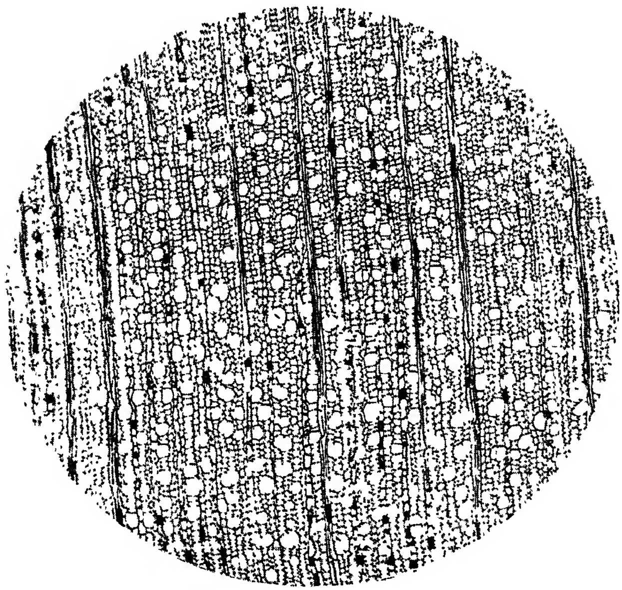


Fig 2.

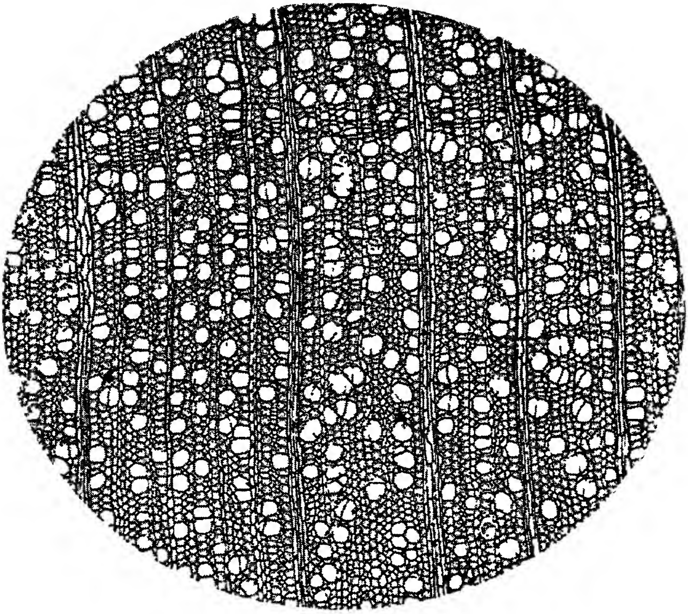
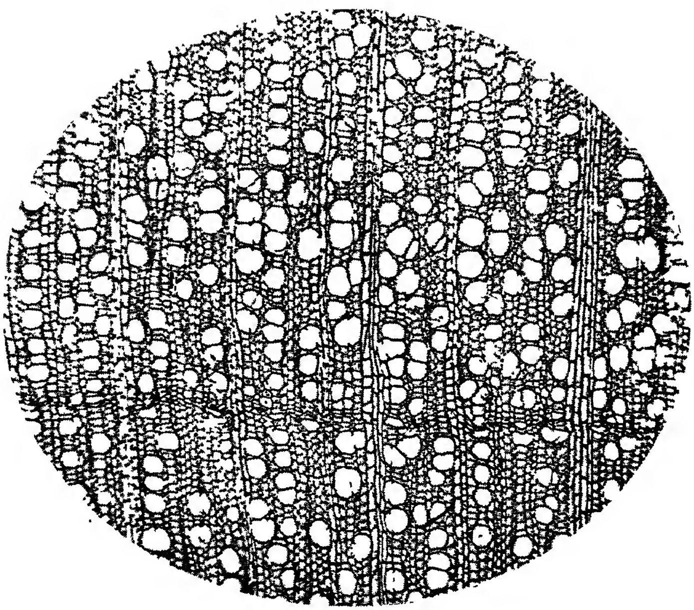


Fig. 3.



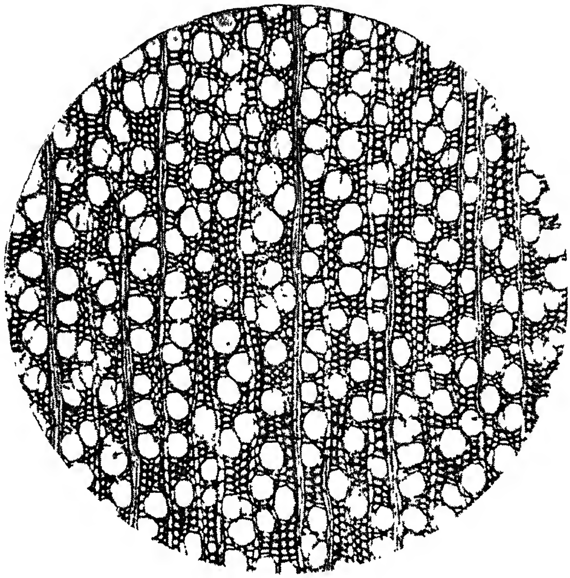
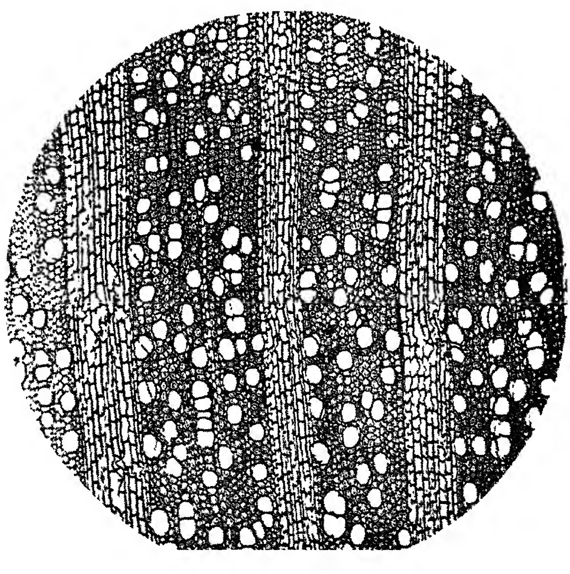
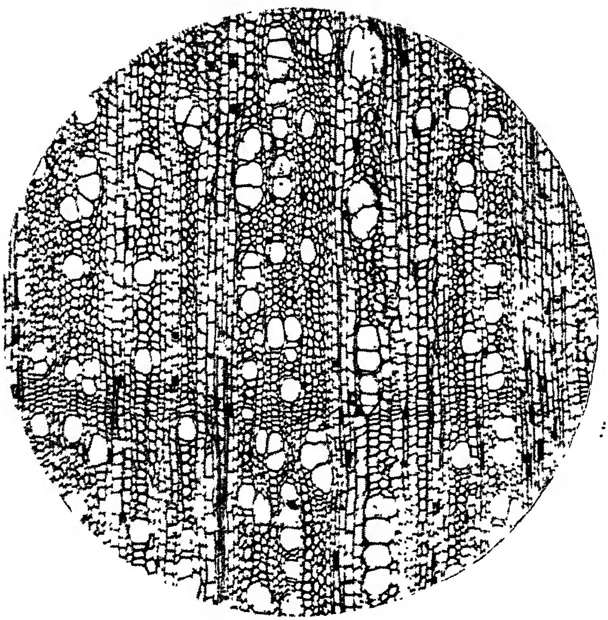


Fig. 5





Fig, 7.

Fig. 3.—Daphnandra micrantha. Transverse section of wood showing even pore distribution and manner of grouping. The wood fibres are extremely thick walled. Near the bottom can be seen the few rows of radially compressed cells indicating the boundary of the growth ring. × 37.

Fig. 4.—Daphnandra repandula. Transverse section of wood showing pore arrangement and their irregular size and shape. The wood fibres are thick walled and also irregular in size and shape. Near the bottom is an indication of a growth ring boundary. × 37.

Fig. 5.—Daphnandra aromatica. Transverse section of wood showing comparatively large pore size and their even distribution; the scalariform bars are frequently visible in the vessels. The wood fibres are comparatively thin walled. × 37.

Fig. 6.—Mollinedia Huegeliana. Transverse section of wood showing small scattered pores, and very thick walled fibres. The large multiseriate rays are prominent, whilst the discontinuous radial rows of parenchyma are visible. × 37.

Fig. 7.—Hedycarya angustifolia. Transverse section of wood showing frequent radial arrangement of pores. The vessels and fibres are thin walled. Wood parenchyma is fairly abundant. The large multiseriate rays are also prominent. × 37.

NOTE ON A FOSSIL SHRIMP FROM THE HAWKESBURY SANDSTONES.

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(Communicated by W. S. Dun.)

(With Plate XXX.)

(Read before the Royal Society of New South Wales, Dec. 5, 1928.)

Towards the end of 1926 I received from Professor Leo Cotton, of Sydney University, a specimen of a fossil shrimp with a request for its examination and the information that it came from a shale band about the middle of the Hawkesbury Sandstones. The specimen was obtained by Mr. William Hatcher from the Brookvale brick quarry and was lent by him to Rev. R. T. Wade for the purpose of description.

A brief preliminary examination seemed to indicate the absence of a carapace and to show that the animal probably belonged to the Anaspidacea while in size and general appearance it reminded me of *Anaspides,* a freshwater shrimp belonging to that group and still living in the streams and lakes of Tasmania. I had formed this tentative conclusion before I was definitely aware that the Hawkesbury Sandstones are freshwater deposits containing remains of plants, freshwater shells, fish, insects, etc. But the specimen had to be laid aside at the time owing to other work. I have now made a further inspection of it and though owing to its state of preservation I am unable to supply much information as to its structure there seems nothing inconsistent with the opinion first arrived at.

The specimen (see plate XXX.) is about two inches in length and has been flattened dorso-ventrally so that the fossil consists only of a rather faint, flat impression showing the outline of the body and some of the appendages, mostly indistinctly. There are no hard parts of the actual animal preserved and it seems possible that the integument was thin and non-calcareous as it is in the existing *Anaspides tasmaniae* (Thomson).

The six segments of the abdomen can be made out fairly distinctly, the first five being subequal in length, the sixth longer and slightly narrower and followed by very indistinct indications of the tail fin. (The distinct rod-like structure to the right of the tail fin is, I think, no part of the animal but some extraneous substance.) The animal appears to have been slightly tilted over to the right and the lateral portions, or epimera, of the three anterior segments of the abdomen show distinctly on the left side and the impressions seem to indicate that in the living animal they were produced downwards about as far as they are in *Anaspides tasmaniae*. Anterior to the abdomen there are on the left side indications of three well marked and distinct segments, the posterior one shorter than the two in front of it and considerably shorter than the first segment of the abdomen. These three segments appear to be the posterior segments of the thorax and the facts that they are free and that there is no indication of a carapace form the chief reasons for supposing the animal to be a member of the *Anaspidacea*.

This supposition seems to be supported by one or two other points that can be made out. Along what appears to be the posterior margin of the sixth abdominal segment are remains of a transverse row of about six minute teeth-like structures which seem to correspond to the row of setae found in *Anaspides tasmaniae* as figured by Thomson

(Trans. Linn. Soc. Zool. vol. VI., plate 25, fig. 9) and Geoffrey Smith (Q.J. Micros. Sci. vol. 53, p. 521, text figure 30). Similar setae fringe the posterior margin of the telson in *Anaspides* and other genera but the end of the telson is not visible in the fossil under examination.

Only a few of the appendages are preserved with any degree of distinctness. The two on the left at the anterior end doubtless represent the antennae, the first showing the joints of the peduncle, the inner, shorter, flagellum and part of the outer flagellum. Similarly in the second there are indications of peduncular joints and, much more distinct, of the basal joints of the multiarticulate flagellum, but there is no sign of the squame. On both sides there are impressions of three pairs of thoracic appendages, one, probably the first, being a little stouter than the others. The antennae and the thoracic appendages show some resemblance to those of *Anaspides* but it must be pointed out that no sign of the exopods and branchial epipods associated with the thoracic appendages of that genus can be made out.

From the foregoing account it will be seen that our knowledge of the animal preserved in this fossil is very imperfect and that it would be absurd to attempt to give any diagnosis of its genus and species. If it must have a name as a matter of convention I suggest that it may be referred to as *Anaspides (?) antiquus*.

Photo by H. G. Gooch. Magnification × 2

CYANOGENETIC GLUCOSIDES IN AUSTRALIAN PLANTS.

By
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Accepted for Publication December 5, 1928.

At the Hobart meeting of the Australian Association for the Advancement of Science an account was given by one of the present writers (H.F.) with Walter Charles Gledhill, of the examination of some sixty species of *Acacia* for cyanogenetic glucosides, and the occurrence of these was recorded in four species, viz., *Acacia glaucescens, A. Cheelii, A. doratoxylon* and *A. Cunninghamii.*[1]

The present account describes the isolation of the glucoside from the two first-named species and its identification with sambunigrin, $C_{14}H_{17}NO_6$, which was first isolated from *Sambucus nigra,* the European elder, by Borquelot and Danjou.[2]

Extraction of the Glucoside.

In our first experiments we followed the time-worn method of extracting the leaves with alcohol, evaporating the extract to a syrup, re-dissolving this in water, and attempting to purify the product by precipitating the tannoid and other impurities with lead acetate followed by lead subacetate. A complex syrup was obtained from which

[1] Aust. Journ. Pharm. 1928, N.S. 9, 174.
[2] Compt. rend. 1905, 141, 598-600.

the pure glucoside could not be separated in quantity, although it was present and showed evidence of crystallisation. We, therefore, decided to try liquids of more limited solvent power, and on extracting the crushed leaves in a Soxhlet apparatus, firstly with petroleum ether to remove fatty matter, then with ether, an abundance of crystalline matter slowly separated during the extraction in a practically pure condition. On washing with solvent to remove mother liquor and recrystallisation from a mixture of ethyl acetate and chloroform, the glucoside separated in long, colourless, silky needles, having no odour, but a taste at first sweet and then bitter. On further recrystallisation it melted at 152°.

(*a*) 0.1964 gave 0.4090 CO_2 and 0.1027 H_2O. C = 56.78 : H = 5.81.

(*b*) 0.1625 gave 0.3380 CO_2 and 0.0848 H_2O. C = 56.72 : H = 5.80.

$C_{14}H_{17}NO_6$ requires C = 56.96 : H = 5.76.

0.4768, dissolved in 50 c.c. absolute alcohol gave in a 2-dcm. tube at 24° α_D — 1.41° whence $[\alpha]_D^{24}$ = — 73.9.

The *acetyl* derivative was prepared by heating 1 gram of the purified glucoside with 10 grams of acetic anhydride and 2 grams of sodium acetate for 45 minutes. After allowing the mixture to cool, water was added and warmed on a water bath for 30 minutes to decompose excess of acetic anhydride; the acetyl derivative separated on cooling in small colourless needles, which after twice crystallising from dilute alcohol melted at 125°.

0.1255 gave 0.2578 CO_2 and 0.0617 H_2O. C = 56.95 : H = 5.55.

$C_{14}H_{13}(COCH_3)_4NO_{10}$ requires C = 57.02 : H = 5.40.

0.4146 dissolved in 50 c.c. absolute alcohol gave in a 2-dcm. tube at 23° α_D — 0.89° whence $[\alpha]_D^{23}$ = — 53.6.

These figures agree with those obtained for sambunigrin, the glucoside of *Sambucus nigra*, and there can be no reasonable doubt as to the identity of the two. For comparison the constants of the two substances and their acetyl derivatives are set out below.

The figures for acetyl-sambunigrin are those found for the synthetic product prepared by Emil Fischer and Bergmann.[3]

	Sambunigrin	Glucoside from *A. glaucescens*
Carbon	56.88	(a) 56.78
		(b) 56.72
Hydrogen	5.83	(a) 5.81
		(b) 5.80
Optical Rotation ..	$[\alpha]^{15}$ – 76.3	$[\alpha]^{24}$ – 73.9
Melting Point ..	Sinters at 149° Melts at 151°-152°	Melts at 152°

	Tetra-acetyl Sambunigrin	Tetra-acetyl derivative of Glucoside from *A. glaucescens*
Optical Rotation..	$[\alpha]^{22}$ – 52.5	$[\alpha]^{23}$ — 53.6
Melting Point ..	125°-126°	125°

Amount of HCN in *Acacia glaucescens.*

In the table A are collected some figures showing the amount of hydrocyanic acid present in this plant. It is too early to say what, if any, significance is attached to the distinct fall in the amount observed in the Spring.

Acacia Cheelii, Blakeley.

We have also isolated sambunigrin from *Acacia Cheelii* by the process described above.

Euphorbia drummondii, Boiss.

Probably few plants in Australia have been the subject of so much controversy as to their toxicity to stock as *Euphorbia drummondi*, the Milk Weed. Maiden[4] reviewing the available evidence stated that thousands of people con-

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3 Ber. d. d. chem. Ges. 1917, 50, 1047.

4 Agric. Gaz. N.S.W. 1897, 8, 18.

TABLE A.

Amount of HCN in *Acacia glaucascens* (phyllodes.)

Reference Number.	Source.	Date Collected	Date Received.	Per cent. moisture lost on air drying.	Per cent. HCN yielded by fresh phyllodes.	Per cent. HCN *calc.* in dried phyllodes.	Per cent. HCN *found* in dried phyllodes.
P.I. 1	Glenfield	Nov. '27	Nov. '27	...	...	...	0.22*
P.I. 32	,,	...	27/3/28	62.5	0.12	0.32	Not done
P.I. 121	,,	...	7/6/28	45.0	0.20	0.37	,,
P I. 199	,,	...	18/7/28	49.8	0.21	0.42	0.41
P.I. 454	,,	24/9/28	5/10/28	31.0	0.08	0.12	0.12

*Determination not carried out until Jan., 1928.

sidered it poisonous, and on the other hand quoted the opinion of the late Mr. Edward Stanley[5], Chief Government Veterinarian of N.S.W., who, after a considerable number of experiments on sheep, failed to produce any poisonous symptoms whatever, and concluded that the reported deaths were due to indigestion or to diseases such as anthrax. In support of the view of the harmlessness of this plant is the common experience of pastoralists of its use as fodder, constituting as it does in certain circumstances, the only food available. In such cases, sheep feeding on it in quantity are subject to the possibility of developing hoven through gorging, just as may happen through the ingestion of excessive amounts of any other harmless green crop.

Other writers in later years have referred to the uncertainty regarding this plant and have stressed the real need for more exact data.

In these circumstances the Poison Plants Committee of the C.S.I.R. decided to undertake its systematic collection and examination, particularly, in the first instance, for

[5] Agric. Gaz. N.S.W. 1896, 7, 619.

hydrocyanic acid. Dr. H. R. Seddon, Director of Veterinary Research, arranged through his Stock Inspectors to collect samples from as wide an area of this State as possible, and in order that there should be no possibility of loss of this volatile acid during transit to the laboratory, it was decided to have the fresh samples placed immediately after collection in bottles securely fastened with india-rubber stoppers.

Dr. Seddon has already reported[6] that one of these samples proved fatal when fed to a sheep, and the symptoms shown were those of prussic acid poisoning. The contents of the stomach were submitted to us by Dr. Seddon, and were found to contain hydrocyanic acid, as did the original specimen of the plant after merely macerating with water, showing that it also contained the enzyme necessary for hydrolysis of the cyanogenetic substance. In the original scheme of collection Dr. Seddon arranged to cover 35 areas coinciding with the same number of Pasture Protection Districts of N.S.W., and although during the past season we examined 113 specimens from these localities, from only one of these, viz., Brewarrina, which includes Bokhara, have we obtained samples containing hydrocyanic acid; in all, 11 positive specimens were collected. During the present season, however, positive samples have been obtained from Dubbo and Merriwa, so that as the area of collection is extended it may be found that the poisonous samples are not so limited in distribution as at first seemed to be the case.

The Brewarrina plants were collected between the 24th April and 28th July, 1928. Previous to the 7th June the cyanogenetic substance in the plant was associated with sufficient enzyme to ensure its decomposition when moistened with water, and differed in this respect from the four

[6] Journ. C.S.I.R. 1928, 1, 268.

species of *Acacia* mentioned above which contained little, if any, enzyme. Samples collected on 10th July, however, were found to be deficient in enzyme and only developed their total amount of hydrocyanic acid after enzyme from almonds had been added.

The amount of hydrocyanic acid obtained from these 11 specimens varied between 0.041 and 0.103 per cent., or 2.8 to 7.2 grains per lb., of the air-dried material; particulars are given in the following table.

TABLE B.

Amount of HCN *Euphorbia Drummondi* (whole plant)

Reference Number.	Source.	Date Collected.	Date Received.	Per cent. moisture lost on air drying.	Per cent. HCN yielded by fresh plant.	Per cent. HCN *calc.* in air dried plant.	Per cent. HCN *found* in air dried plant.
P.I. 60	Brewarrina	24/4/28	27/4/28	61.0	0.033	0.085	Insufficient material to carry out.
P.I. 61	Bokhara	,,	,,	65.5	0.036	0.103	
P.I 96	Brewarrina	8/5/28	24/5/28	23.5	0.066	0.086	
P.I. 97	Bokhara	,,	,,	23.5	0.058	0.077	
P.I. 138	Brewarrina	7/6/28	15/6/28	44.9	0.055	0.097	0.099*
P.I. 139	Bokhara	,,	,,	39.4	0.053	0.088	0.091*
P.I. 195	Bokhara	10/7/28	13/7/28	3.0	0.039	0.041	...
P.I. 196	Brewarrina	,,	,,	21.8	0.046	0.059	...

*After drying for 36 days.

The problem whether there is any ascertainable botanical difference between the samples containing hydrocyanic acid and those which do not is being undertaken by Dr. G. P. Darnell-Smith, who has kindly examined all the above specimens as to their identity.

Goodia lotifolia, Salisb.

In a series of Botanical Notes published in 1895 the late Mr. J. H. Maiden[7] included a note entitled "Is Goodia poisonous to Stock?", and although he did not attempt to answer this question in the affirmative, he adduced evidence to show that the plant was under strong suspicion, but that opinion was divided on the subject.

Goodia is a genus of the Leguminosae, only two species of which, *G. lotifolia* (Salisb.), syn. *G. medicaginea* and *G. pubescens* have been recorded. Indeed, the latter is thought by some botanists to be a pubescent form of the first. They are confined to Australia and occur as tall shrubs, the former growing to the size of a small tree and is the only one occurring in this State. In Tasmania it is known as the clover tree, from the similarity of its delicate leaves to clover. In Queensland its aboriginal name is *Booroo-molie*.

Some of the foregoing particulars are due to Mr. Maiden, who gave an account of an enquiry from Bega respecting this shrub, known locally as the Indigo, the foliage of which was frequently fatal to stock travelling from Monaro to the coast. Large quantities at that time grew on the main road between Colombo and Nimitybelle. The same enquirer stated that cattle ate this plant greedily, and suffered from what was termed black scour—the tongue became black, the hide acquired a bluish tint and appeared rough and bound, the cattle became weak and emaciated, and eventually died. The form *G. medicaginea* has also been suspected in West Australia, twenty-five head of cattle dying from stoppage of the bowels. Another case of poisoning occurred in South Australia, and a correspondent from Yorketown submitted to the Agricultural Bureau of

7 Agric. Gaz. N.S.W. 1895, 6, 306.

that State a specimen of a plant supposed to be poisonous, which was identified by the General Secretary of the Bureau as a species of *Goodia* and pronounced to be quite harmless. Mr. Maiden quotes the evidence of several South Australian observers who had fed this plant to animals without ill effect.

Such were the conflicting views of the toxicity of the *Goodias* when a specimen of *G. lotifolia* gathered near Middle Harbour in August of this year, just before flowering, proved to be strongly cyanogenetic. A quantitative estimation of the amount of hydrocyanic acid showed that the fresh leaves gave 0.23 per cent., which is equivalent to 0.57 per cent. calculated on the air-dried leaves. This amount is larger than that recorded in any Australian plant with the exception of *Heterodendron oleæfolia* found by Petrie to contain 0.328 per cent.[8] That this specimen is not unique in being cyanogenetic is shown from the fact that plants collected from such widely separated localities as the Botanic Gardens, Sydney and Melbourne, Mount Lindsay (Queensland)[9], Kangaroo Island (South Australia), and Braidwood (N.S.W.) were all strongly cyanogenetic.

It is of interest to record that specimens obtained from the Herbarium of the Botanic Gardens, Sydney, through the courtesy of Dr. G. P. Darnell-Smith, and from the Herbarium of the Technological Museum, Sydney, through the kindness of Mr. M. B. Welch, all failed to develop hydrocyanic acid when treated, as were the fresh plants, with water alone, or even when emulsin derived from sweet almonds was added. Whether a cyanogenetic glucoside had ever been present in these Herbarium specimens is

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8 Proc. Linn. Soc. N.S.W. 1920, 45, 447.

9 We are indebted to Mr. J. C. White, Queensland Government Botanist, for kindly locating this specimen.

unknown, but it seems likely that our failure to detect it was due to its loss during keeping. In confirmation of this view we may quote one experiment in which it was found that after drying the leaves in the air for one month the amount of hydrocyanic acid had fallen from 0.57 to 0.18 per cent.

Poranthera microphylla.

In the course of investigating as many plants as possible for hydrocyanic acid, this plant also was found to be cyanogenetic. So far as is known it has not proved fatal to stock, and being small and sparsely distributed it would not seem to be dangerous. Indeed the collection of a few pounds for analysis requires much patience. Many samples growing near Middle Harbour have been examined, always with a positive result. One quantitative examination showed that the whole plant yielded 0.018 per cent. of hydrocyanic acid calculated on the fresh, or 0.051 on the air-dried material. All Herbarium specimens have so far proved negative.

Poranthera corymbosa also yields a very faint positive reaction.

Eucalyptus corynocalyx.

In times of drought this tree, known as the Sugar Gum, which is practically free from volatile oil, is fed to stock, and fatal results have been observed. A specimen from South Australia, for which we are indebted to Professor T. G. B. Osborn, was nearly dry when received. It yielded 0.179 per cent. of hydrocyanic acid. A specimen from an ornamental grove growing in a street at Ashfield, for which we are indebted to Mr. E. Cheel, was also positive, as were eight Herbarium specimens from the Botanic Gardens, Sydney.

Further investigation of these plants is proceeding.

The authors acknowledge with grateful thanks their indebtedness to Professor J. C. Earl for placing the facilities of his laboratory for the analysis of sambunigrin at their disposal, and to the Council for Scientific and Industrial Research for a grant to the Poison Plants Committee that has enabled one of them (C.B.C.) to collaborate in this work.

Department of Materia Medica and Pharmacy,
The University, Sydney.

ABSTRACT OF PROCEEDINGS

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

MAY 2, 1928.

The Annual Meeting, being the four hundred and seventy-sixth General Monthly Meeting of the Society, was held at the Royal Colonial Institute, 17 Bligh Street, Sydney, at 8 p.m.

Professor J. Douglas Stewart, President, in the Chair.

Forty-three members were present.

The Minutes of the General Monthly Meeting of the 7th December, 1927, were read and confirmed.

It was announced that the following members had died during the recess:—Robert Houston Barr, Alfred John Cape, Launcelot Harrison, William Joseph Scammell, George Augustine Taylor, James Taylor and William Welch.

Letters were read from Mrs. Harrison, Mrs. Balfern, Mrs. Scammell, Mrs. Florence Taylor, Mrs. James Taylor and Mrs. W. Welch, expressing thanks for the Society's sympathy in their recent bereavements.

The certificates of two candidates for admission as ordinary members were read for the first time.

The following gentleman was duly elected an honorary member of the Society:—Grafton Elliot Smith, M.A., M.D., F.R.S., F.R.C.P., Professor of Anatomy in the University College, London.

The Annual Financial Statement for the year ended 31st March, 1928, was submitted to members, and, on the motion of Professor Chapman, seconded by Mr. Andrews, was unanimously adopted.

GENERAL ACCOUNT.

RECEIPTS.

	£	s.	d.	£	s.	d.	£	s.	d.
To Revenue—									
Subscriptions				709	16	0			
Rents—									
Offices	576	1	0						
Hall and Library ..	266	5	7						
				842	6	7			
Sundry Receipts ..				90	0	4			
Advance on Government Subsidy for 1927 ..				200	0	0			
Interest — Government Bonds and Stock ..				43	3	0			
							1885	5	11
,, Donations—									
Walter Burfitt Prize Fund	500	0	0						
Add—Interest	10	11	9						
				510	11	9			
H. Minton Taylor and J. J. Mulligan				250	0	0			
							760	11	9
,, J. H. Maiden Memorial Fund							75	15	0
,, Clark Memorial Fund— Loan to General Fund							72	7	0
,, Investment Fund							189	0	0
,, Royal Society House—									
Proceeds of Sale				28000	0	0			
Less—Commission ..				430	0	0			
							27570	0	0
							£30552	19	8

PAYMENTS.

	£	s.	d.	£	s.	d.	£	s.	d.
By Balance—31st March, 1927							980	15	11
„ Administrative Expenditure—									
Salaries and Wages—									
Office Salary and Accountancy Fees ..	291	15	0						
Assistant Librarian ..	53	0	0						
Caretaker	277	12	9						
				622	7	9			
Printing, Stationery, Advertising & Stamps									
Stamps & Telegrams	40	0	0						
Office Sundries, Stationery, etc.	9	15	4						
Advertising	10	7	0						
Printing	81	4	3						
				141	6	7			
Rent, Rates, Taxes and Services—									
Rent	110	6	8						
Electric Light	66	13	6						
Gas	12	12	0						
Insurance	32	4	10						
Rates	320	17	6						
Telephone	15	1	8						
				557	16	2			
Printing & Publishing Society's Volume—									
Printing, etc.	348	6	6						
Bookbinding	48	8	4						
				396	14	10			
Library—									
Books and Periodicals	4	5	8						
Bookbinding	95	3	9						
				99	9	5			
Sundry Expenses—									
Repairs	2	12	6						
Lantern Operator ..	21	13	0						
Bank Charges	0	5	5						
Sundries	66	7	0						
				90	17	11			
							1908	12	8

	£	s.	d.	£	s.	d.
„ Interest—						
Union Bank of Australia Ltd. ..	32	15	6			
Clarke Memorial Fund	72	7	0			
Building Loan Fund	58	5	0			
Maiden Memorial Fund	28	10	0			
				191	17	6
„ Building and Investment Loan Fund				1153	8	7
„ Building and Investment Fund ..				189	0	0
„ Government Bonds and Stock				25076	0	11
„ Balance—						
Union Bank of Australia Ltd. ..	1049	11	4			
Cash on hand	3	12	9			
				1053	4	1
				£30552	19	8

Compiled from the Books and Accounts of the Royal Society of New South Wales, and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D., Honorary Treasurer.

(Sgd.) W. PERCIVAL MINELL, F.C.P.A., Auditor.

Sydney, 19th April, 1928.

BALANCE SHEET AS AT 31st MARCH, 1928.

LIABILITIES.

	£	s.	d.	£	s.	d.
Sundry Creditors—						
Weldon & Wesley	0	10	9			
Rent	108	6	8			
				108	17	5
Investment Fund—						
Clarke Memorial Fund	1169	10	3			
Walter Burfitt Prize Fund	510	11	9			
Investment Fund	3230	9	9			
				4910	11	9
Building and Investment Loan Fund ..				378	1	7
J. H. Maiden Memorial Fund				342	13	0
Accumulated Funds				30455	14	2
				£36195	17	11

ASSETS.

	£	s.	d.	£	s.	d.
Cash—						
Union Bank of Australia, Ltd. ..	1049	11	4			
Petty Cash	3	12	9			
				1053	4	1
Government Bonds and Stock				25076	0	11
Sundry Debtors—						
For Rents	128	10	11			
For Subscriptions in arrears	399	2	0			
				527	12	11

	£	s.	d.
Library—			
Insurance Valuation	8060	0	0
Office Furniture—Insurance Valuation..	1139	0	0
Pictures—Insurance Valuation	180	0	0
Microscopes—Insurance Valuation ..	120	0	0
Lantern—Insurance Valuation	40	0	0
	£36195	17	11

CLARKE MEMORIAL FUND.

BALANCE SHEET AS AT 31st MARCH, 1928.

LIABILITIES.

	£	s.	d.	£	s.	d.
Accumulation Fund—						
Balance as at 31st March, 1927 ..	1097	3	3			
Additions during the year—						
Interest and General Fund ..	72	7	0			
				1169	10	3
				£1169	10	3

ASSETS.

	£	s.	d.
Transferred to Investment Fund	1169	10	3
	£1169	10	3

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31st MARCH, 1928.

RECEIPTS.

	£	s.	d.
To Interest—Loan to General Fund	72	7	0
	£72	7	0

PAYMENTS.

	£	s.	d.
By Loan to General Fund	72	7	0
	£72	7	0

INVESTMENT FUND.

BALANCE SHEET AS AT 31st MARCH, 1928

	£	s.	d.	£	s.	d.
Balance as at 31st March, 1927				1000	0	0
Additions during the year—						
Life Subscriptions	189	0	0			
Transfer from General Fund, as per minute dated 28th March, 1928	2041	9	9			
Transfer from Clarke Memorial Fund	1169	10	3			
Transfer from Walter Burfitt Prize Fund	510	11	9			
				3910	11	9
				£4910	11	9

	£	s.	d.
Commonwealth and New South Wales Government Bonds	4910	11	9
	£4910	11	9

Compiled from the Books and Accounts of the Royal Society of New South Wales, and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D., Honorary Treasurer.

(Sgd.) W. PERCIVAL MINELL, F.C.P.A., Auditor.

Sydney, 19th April, 1928.

On the motion of Professor Chapman, seconded by Mr. Challinor, Mr. W. P. Minell was duly elected Auditor for the current year.

The Hon. Treasurer announced the receipt of a gift of £250 from Messrs. J. J. Mulligan and H. Minton Taylor.

The President announced that an intimation had been received that the late Professor Archibald Liversidge made a bequest to this Society of £500 to found a Research Lectureship in Chemistry. Conditions governing the lectureship as provided by Professor Liversidge are set out in the Annual Report of the Council for 1927-28.

The Annual Report of the Council was read, and on the motion of Mr. Cambage, seconded by Mr. Sussmilch, was adopted.

Report of the Council for the Year 1928-29.

(1st May to 23rd April.)

The Council regrets to report the loss by death of twelve ordinary members. Eight members have resigned, and six members were removed from the roll owing to non-payment of subscriptions. On the other hand, twelve ordinary members have been elected during the year. To-day (23rd April, 1928) the roll of members stands at 346.

During the Society's year there have been eight general monthly and eleven Council meetings.

Sale of Royal Society's House.—On 21st October, 1927, the Council sold the Society's House to the Adult Deaf and Dumb Society, but have arranged to retain possession of the building with the exception of the first floor until 31st December, 1928.

Science House.—Discussion of the question of building a Science House to house the various scientific bodies of Sydney has been continued with the Linnean Society of New South Wales and the Institution of Engineers, Australia, but final arrangements have not yet been made. The Government of New South Wales has notified the Society by letter dated 28th July, 1927, that it has decided to make available free of charge a block of land for the purpose of a Science House at the corner of Essex and Gloucester Streets. Arrangements in regard to this matter have not yet been finalised.

Four Popular Science Lectures were given, namely:—

June 16—"A Glance at Japan," by R. H. Cambage, C.B.E., F.L.S.

July 21—"Earth Waves and Earth Ripples," by Edgar H. Booth, M.C., B.Sc., F.Inst.P.

August 18—"Some Observations on Disease in Plants," by R. J. Noble, B.Sc., Ph.D.

September 15—"What Makes a Good Food," by Professor H. G. Chapman, M.D.

On October 31st, 1927, a lecture was given by Dr. Rudolf Krahmann, Lecturer on Engineering Science and Geophysics in the Technical University, Berlin, entitled: "Subterranean Survey by Geophysical Methods."

Meetings were held throughout the Session by the Sections of Geology, Agriculture and Physical Science.

The Section of Industry during the year devoted its attention to visiting several industrial establishments.

Twenty-three papers were read at the monthly meetings and covered a wide range of subjects. In most cases they were illustrated by exhibits of interest.

Lecturettes were given at the monthly meetings in August, September, October and December, by Professor O. U. Vonwiller, Mr. Robert Grant, Professor R. D. Watt and Mr. I. Clunies Ross respectively. At the November meeting a cinema demonstration was given on the preparation of biological products.

The Annual Dinner took place at the Union Refectory, Sydney University, on 28th April, 1927, when we were honoured by the presence of His Excellency Sir Dudley Rawson Stratford de Chair, K.C.B., M.V.O., Governor of New South Wales, Professor F. P. Sandes, M.D., Ch.M., B.Sc., Acting Director of Cancer Research, Sydney University, and the Presidents of several societies.

The Council has awarded the Clarke Memorial Medal to Ernest Clayton Andrews, B.A., F.G.S.

An intimation has been received that the late Professor Archibald Liversidge made a bequest to this Society as set out in the following extract from the Will dated 16th August, 1925:—

> 9. (A) I BEQUEATH five hundred pounds to each of the four following Institutions, namely, The University of Sydney aforesaid, The Royal Society of New South Wales, Sydney, aforesaid, The Australasian Association for the Advancement of Science, Sydney, aforesaid, and The Chemical Society of London, to found a Research Lectureship in Chemistry in connection with each of these Institutions.
>
> (C) AND I DECLARE that the bequests made by this Claim are not intended to supplement the emoluments or add to the duties of any member of the ordinary or permanent teaching staff of any institution (including the said College) mentioned in this Clause.
>
> 10. I make the above bequests for the encouragement of research in Chemistry not in ignorance of the fact that there are already in existence other Lectureships

in Chemistry but because there are none such as I contemplate, namely, for the express encouragement of research and for the purpose of drawing attention to the research work which should be undertaken and because having regard to the vastness of the subject I wish the subject to be elucidated by as many workers as possible and feel that the friendly emulation of the lecturers holding the various lectureships above-mentioned may be of benefit.

11. I DIRECT that the lectures to be given by the persons holding the said Lectureships respectively shall not be such as are termed popular lectures dealing with generalities and giving mere reviews on their subjects nor such as are intended for the ordinary class or lecture room instructions of undergraduates but shall be such as will primarily encourage research and stimulate the Lecturer and the public to think and acquire new knowledge by research instead of merely giving instruction in what is already known AND I DIRECT that the Lecturers appointed shall be the most suitable and eminent men procurable in their respective branches of knowledge.

12. I HEREBY lay down the following rules in connection with the said Lectureships, not with the intention of imposing any legal and binding restrictions or obligation in regard thereto but merely as an indication of my wishes—

(a) NO lecturer shall hold office for more than one year but after intervals of two or more years during which time he shall not have held any of the Lectureships founded under this my Will in any of the said Institutions he may be re-appointed from time to time if then still considered by the Institution the most suitable person obtainable.

(b) The remuneration paid to each Lecturer shall not be less than Ten pounds nor more than Twenty-five pounds for each lecture delivered by him and if the annual income of the Lectureship is insufficient the lectures can be given in alternate years.

(c) The number of lectures in each course shall ordinarily be one or more but not more than three.

(d) If possible the Lectures shall be delivered in the evening at the Institution receiving the legacy to found the lectureship and if that Institution does not itself possess a sufficiently large room then in some other suitable and conveniently situated building.

(e) The lecture hall (under suitable regulations) be open to the public free or at a nominal fee to cover incidental expenses such as the hire of the hall.

(f) If possible the lecture shall be published in a cheap form so as to disseminate the information for the benefit of such of the public as are unable to attend and the Lecturer shall in every case be required to present to the Institution concerned a correct and complete copy of his lectures for the above purpose.

(g) The Lectures shall be upon recent researches and discoveries and the most important part of the Lecturer's duty shall be to point out in which directions further researches are necessary and how he thinks they can best be carried out.

(h) If for any reason the whole of the interest on any of the above bequests cannot be utilised as above prescribed in any year or years the unexpended part thereof shall be invested and added to the sum originally bequeathed.

(i) Christ's College, Cambridge, may in their discretion arrange for their lectures to be delivered during the meetings of the Summer School for Teachers in the long vacation.

(j) The said Institutions may appoint delegates to form committees or confer by correspondence to carry out all or any of the above objects with a view to preventing overlapping and generally carrying out my intentions in regard to the said lectures.

13. I DECLARE as follows:—

(i) In the case of any infant legatee under this my Will or any Codicil hereto my Trustees in their absolute discretion may pay his or her legacy to any parent, guardian or guardians of his or hers and the receipt of any such parent, guardian or guardians shall be a completed discharge to my Trustees for the legacy.

(ii) In the case of any Institution, College, Society or body (whether or not incorporated) to which or to whom any legacy or property is bequeathed or given by this my Will or any Codicil hereto the receipt of the Secretary, Treasurer, Bursar or any other officer for the time being of such Institution, College, Society or body shall be a complete discharge to my Trustees for the said legacy or

property and shall free them from all further concern with the trusts or application thereof

(iii) THE foregoing legacies and annuities shall rank and be satisfied in the following order of priority that is to say FIRST the said specific legacies and annuities bequeathed by Clauses 3, 4, and 6 hereof with the death duties in respect thereof; SECONDLY the pecuniary legacies bequeathed by Clauses 5 hereof with the death duties in respect thereof (all ranking pari passu inter se), and THIRDLY the pecuniary legacies bequeathed by Clauses 7, 8, and 9 hereof with the death duties in respect thereof (all ranking pari passu inter se).

At the last Annual Meeting in May, 1927, it was announced that Dr. Walter Burfitt would donate £500 to be devoted to the establishment of a "Walter Burfitt Prize" to be awarded from time to time by the Council of the Royal Society of New South Wales at its discretion to a person residing in the Commonwealth of Australia or the Dominion of New Zealand for meritorious service in the cause of science. The prize to be awarded for either pure or applied science.

Since that date the amount, £500, has been received.

Sir Richard Threlfall, G.B.E., an honorary member of this Society, has been created a Knight Grand Cross of the Most Excellent Order of the British Empire.

The donations to the library have been as follows:—1265 parts, 56 volumes, 46 reports, 7 maps and 4 catalogues.

It was announced that the Council had awarded the Clarke Memorial Medal to Mr. E. C. Andrews, B.A., F.G.S., and the President then made the presentation. Mr. Andrews expressed his appreciation of the Council's action in making the award.

The President announced that the Maiden Memorial Fund was about to close, and that the committee would be glad to receive any further contributions in order that

action might proceed towards the erection of a Maiden Memorial Pavilion in the Botanic Gardens, Sydney.

The following donations were laid upon the table:—395 parts, 27 volumes, 9 reports, 1 calendar and 1 catalogue.

The President, Professor J. Douglas Stewart, then delivered his Address.

There being no other nominations, the President declared the following gentlemen to be officers and Council for the coming year:—

President:

W. POOLE, M.E., M.Inst.C.E., M.I.M.M., etc.

Vice-Presidents:

R. H. CAMBAGE, C.B.E., F.L.S.
C. ANDERSON, M.A., D.Sc.
Prof. R. D. WATT, M.A., B.Sc.
Prof. J. DOUGLAS STEWART, B.V.Sc., M.R.C.V.S.

Hon. Treasurer:

Prof. H. G. CHAPMAN, M.D.

Hon. Secretaries:

Prof. O. U. VONWILLER, B.Sc., F.Inst.P.
C. A. SUSSMILCH, F.G.S.

Members of Council:

E. C. ANDREWS, B.A., F.G.S.
G. H. BRIGGS, B.Sc., Ph.D.
R. W. CHALLINOR, F.I.C., F.C.S.
E. CHEEL.
Prof. L. A. COTTON, M.A., D.Sc.
Prof. C. E. FAWSITT, D.Sc., Ph.D.
G. A. JULIUS, B.Sc., M.E., M.I.Mech.E.
J. NANGLE, O.B.E., F.R.A.S.
R. J. NOBLE, M.Sc., B.Sc.Agr., Ph.D.
Rev. E. F. PIGOT, S.J., B.A., M.B.

Professor J. Douglas Stewart, the out-going President, then installed Mr. W. Poole as President for the ensuing year, and the latter briefly returned thanks.

On the motion of Sir Edgeworth David, a hearty vote of thanks was accorded to the retiring President for his valuable address.

Professor Stewart briefly acknowledged the compliment.

Professor Chapman moved that the meeting place on record its appreciation of the debt which the Royal Society of New South Wales owed to the retiring Honorary Secretary, Mr. R. H. Cambage, for the work done during his long term of office, pointing out that the excellent position in which the Society found itself that day was due in no small measure to the able administration, wise counsel and untiring efforts of Mr. Cambage.

JUNE 6, 1928.

The four hundred and seventy-seventh General Monthly Meeting was held at the Royal Colonial Institute, 17 Bligh Street, Sydney, at 8 p.m.

Mr. W. Poole, President, in the Chair.

Twenty-four members and eight visitors were present, including Mr. A. Broughton Edge, of London, Director, Imperial Geophysical Experimental Survey, who was welcomed by the President.

The Minutes of the preceding meeting were read and confirmed.

The certificates of five candidates for admission as ordinary members were read: two for the second and three for the first time.

The following gentlemen were duly elected ordinary members of the Society:—George Walter Cansdell Hirst and Theodore George Bently Osborn.

A letter was read from Mrs. Cape, expressing thanks for the Society's sympathy in her recent bereavement.

The President announced that the following Popular Science Lectures would be delivered this Session:—

June 21—"Science and Industry," by Assoc.-Professor F. A. Eastaugh, A.R.S.M., F.I.C.

July 19—"Australian Butterflies," by G. A. Waterhouse, D.Sc., B.E.

August 16—"Elements of Geophysical Prospecting," by E. C. Andrews, B.A., F.G.S.

September —"Some Problems of the Grazing Industry in Arid Australia," by Professor T. G. B. Osborn, D.Sc., F.L.S.

THE FOLLOWING PAPER WAS READ:

"The Chemistry of Western Australian Sandalwood Oil," Part I, by A. R. Penfold, F.C.S.

Remarks were made by Messrs. W. M. Doherty, H. Finnemore and R. Grant.

EXHIBIT:

Sir Edgeworth David gave an account, illustrated with slides and exhibits, of the recently announced discovery of Pre-Cambrian fossils in South Australia.

A lecturette entitled "Solar Radiation in relation to Sun-spots and Weather," was given by Mr. C. A. Sussmilch.

The President announced that the general monthly meetings for the remainder of the year would be held in the Hall of No. 5 Elizabeth Street, Sydney.

JULY 4, 1928.

The four hundred and seventy-eighth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Mr. W. Poole, President, in the Chair.

Twenty-eight members and four visitors were present.

The Minutes of the preceding meeting were read and confirmed.

The President tendered a cordial welcome to Dr. C. M. Yonge and Mr. F. S. Russell, of the British Great Barrier Reef Expedition.

The certificates of three candidates for admission as ordinary members were read for the second time.

The following gentlemen were duly elected ordinary members of the Society:—Walter Charles Davidson, Allan Clunies Ross and Frederick Abbey Wiesener.

The President announced that Dr. G. A. Waterhouse would deliver a Popular Science Lecture entitled "Australian Butterflies," on Thursday, 19th July, 1928.

It was also announced that Sir John Russell, O.B.E., D.Sc., F.R.S., Director of Rothamsted Experimental Station, would deliver a lecture on "Recent Developments in Soil Science," in the Veterinary School, University of Sydney, on Tuesday, 10th July, at 8 p.m.

THE FOLLOWING PAPERS WERE READ:

1. "The occurrence of a number of varieties of *Eucalyptus dives* as determined by chemical analysis of the Essential Oils," Part II, by A. R. Penfold, F.A.C.I., F.C.S., and F. R. Morrison, A.A.C.I., F.C.S.

Remarks were made by F. R. Morrison, Professor Fawsitt, Messrs. E. Cheel, R. W. Challinor and R. T. Baker.

2. "Some observations on the Woodiness or Bullet Disease of Passion Fruit," by R. J. Noble, Ph.D., M.Sc., B.Sc.Agr.

Remarks were made by the President.

LECTURETTES:

1. "Virus Diseases in Plants" (supplementary to the above paper), by R. J. Noble, Ph.D.
2. "Some Recent Discoveries concerning the Star Sirius," by J. Nangle, O.B.E., F.R.A.S.

EXHIBIT:

Mr. F. A. Coombs exhibited tanned skins of sharks of various kinds found in local waters.

AUGUST 1, 1928.

The four hundred and seventy-ninth General Monthly Meeting was held at the Royal Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. W. Poole, President, in the Chair.

Twenty-five members and two visitors were present.

The Minutes of the preceding meeting were read and confirmed.

The President tendered a cordial welcome to Mr. G. W. English, Mineralogist in the University of Rochester, New York, U.S.A.

The certificate of one candidate for admission as an ordinary member was read for the first time.

On behalf of the Council, the President gave notice of the following motion to be submitted at the next general meeting:—

"That the funds of the Society shall be lodged at a bank named by the Council of Management. Claims against the Society when approved by the Council shall be paid by cheque signed by two of three members nominated by the Council for that purpose."

The President announced that Mr. E. C. Andrews, B.A., F.G.S., would deliver a Popular Science Lecture entitled "Elements of Geophysical Prospecting," on Thursday, 23rd August, 1928.

A letter was read from Professor Grafton Elliot Smith thanking the Society for electing him an Honorary Member.

It was announced that the Council of the Royal Society had adopted the following conditions for the award of the Walter Burfitt Prize:—

1. The Walter Burfitt Prize shall be awarded at intervals of three years to the worker in pure or applied science, resident in Australia or New Zealand, whose

papers and other contributions published during the past three years are deemed of the highest scientific merit, account being taken only of investigations described for the first time and carried out by the author mainly in these Dominions.

2. The prize may be awarded to two authors working in collaboration.

3. The prize shall consist of a medal and a sum of £50;

and that the Council had decided that the Australian National Research Council, New Zealand Institute, the Royal Societies of the various States and other scientific bodies in Australia and New Zealand should be invited to submit the names and publications of workers whom they deem worthy of consideration and that scientific workers generally should be invited to submit their publications directly, while the Royal Society might award the prize to a worker whose name has not been submitted to it; and further that the first award should be made in May, 1929, for work published during the three years ending on 31st December, 1928, and that nominations and publications should be submitted to the Royal Society not later than 28th February, 1929.

THE FOLLOWING PAPERS WERE READ:

1. "Brown Rot of Fruits and Associated Diseases in Australia," Part I, by T. H. Harrison, B.Sc.Agr.

Remarks were made by Dr. Dixson.

2. "Acacia Seedlings," Part XIII, by R. H. Cambage, C.B.E., F.L.S.

EXHIBIT:

Exhibit of Tables of Metrology and of Ancient Weights and Measures, prepared by Mr. T. Ranken and presented by him to the Royal Society of New South Wales.

An enlargement of the Society's portrait of the late Lawrence Hargrave, prepared by the Government Printer, through the efforts of Mr. A. R. Penfold, was exhibited to members. The President spoke briefly on the outstanding importance of Mr. Hargrave's contributions to the development of aviation.

SEPTEMBER 5, 1928.

The four hundred and eightieth General Monthly Meeting was held at the Society's Rooms, 5 Elizabeth Street, at 8 p.m.

Mr. W. Poole, President, in the Chair.

Thirty-three members and one visitor were present.

The Minutes of the preceding meeting were read and confirmed.

The certificates of four candidates for admission as ordinary members were read: one for the second and three for the first time.

The following gentleman was duly elected an ordinary member of the Society:—Stanley William Enos Parsons.

The President, on behalf of the Council, moved the alteration of Rule 36, of which notice had been given at the previous meeting, namely:—

That Rule 36 be altered to read as follows:—

> "The funds of the Society shall be lodged at a bank named by the Council of Management. Claims against the Society when approved by the Council shall be paid by cheque signed by two of three members nominated by the Council for that purpose."

This was seconded by Mr. Olle and carried unanimously, thirty-three members present voting. The President announced that the resolution would be submitted for confirmation at the next annual meeting.

The President announced that Professor T. G. B. Osborn, D.Sc., F.L.S., would deliver a Popular Science Lecture entitled "Some Problems of the Grazing Industry in Arid Australia," on Thursday, 20th September, 1928.

THE FOLLOWING PAPERS WERE READ:

1. "The Geology of Port Stephens," by C. A. Sussmilch, F.G.S., W. Clark and W. A. Greig.

Remarks were made by Professor Cotton and Mr. G. D. Osborne.

2. "The Outbreak of Springs in Autumn," by R. H. Cambage, C.B.E., F.L.S.

Remarks were made by the President.

LECTURETTE AND EXHIBITS:

Professor O. U. Vonwiller gave lecturettes with exhibits on (a) "The Knipp α Ray Track Apparatus," and

(b) "Some Pin-hole Phenomena." It was shown that, with a pin-hole placed close to the eye, it was possible to view objects at a very short distance giving greatly increased magnification and, if the pin-hole were small enough, resolving power greatly in excess of that of the unaided eye. Likewise it was possible to obtain photographic enlargements with the plate of the camera placed at the focal plane, the lens being stopped with a very small pin-hole and the portion of the plate to be enlarged being placed a very short distance beyond this, a magnification of 40 or more being readily obtained with satisfactory detail.

Mr. E. Cheel exhibited abnormal specimens of waratah flowers.

The medals of the late Professor Archibald Liversidge bequeathed to this Society were exhibited to members, and the President spoke of his work for the Royal Society and his continued interest in it after leaving Australia.

OCTOBER 3, 1928.

The four hundred and eighty-first General Monthly Meeting was held at the Royal Society's Rooms, 5 Elizabeth Street, at 8 p.m.

Mr. W. Poole, President, in the Chair.

Twenty-three members and four visitors were present.

The Minutes of the preceding meeting were read and confirmed.

The certificates of four candidates for admission as ordinary members were read: three for the second, and one for the first time.

The President announced that a ceremony to commemorate the 200th Anniversary of the birth of Captain James Cook had been arranged by the Royal Australian Historical Society with co-operation of other bodies to take place at the Captain Cook Statue in Hyde Park on 27th October, 1928. He announced further that the next general monthly meeting of the Society would be a Cook Memorial meeting, details of which would be arranged and communicated later.

THE FOLLOWING PAPER WAS READ:

"Description of three new species of Eucalyptus and one new Acacia," by W. F. Blakely.

Remarks were made by Mr. Cambage.

LECTURETTE:

Professor J. C. Earl gave a lecturette (illustrated with lantern slides) on "Glucose and Substances related to it."

EXHIBITS:

1. Sir Edgeworth David exhibited some specimens of fossil remains of highly organised animals recently discovered by him in South Australian Pre-Cambrian rocks.

2. Mr. R. H. Cambage exhibited several plants of *Acacia rubida* which, although ultimately a phyllodineous species, were flowering while wholly in the bipinnate stage and before any phyllodes had appeared. The plants were collected in a sheltered valley at Mittagong, and he had previously recorded the occurrence of this feature from Woodford in a similar situation. ("Dimorphic foliage of *Acacia rubida,* and fructification during bipinnate stage," by R. H. Cambage, these Proceedings, 1914, 48, p. 136.)

NOVEMBER 7, 1928.

The four hundred and eighty-second General Monthly Meeting was held at the Royal Society's Rooms, 5 Elizabeth Street, at 8 p.m.

Mr. W. Poole, President, in the Chair.

Eighty-three present, including many visitors.

The President announced that the formal business of the ordinary general monthly meeting would be deferred until the December meeting.

The reading of papers accepted for this meeting would likewise be postponed until that meeting.

It was announced that apologies for absence were received from the Governor-General, the Lieutenant Governor, the Premier, the Chief Justice and many others.

The business of the evening was the celebration of the bi-centenary of the birth of Captain James Cook.

Addresses were given as follows:—

Surveying and Charting.—The President (Mr. W. Poole, M.E., M.Inst.C.E.).

Astronomy—Mr. Walter Gale, F.R.A.S.

Geographical Discoveries—Sir Edgeworth David, K.B.E., C.M.G., F.R.S.

Hygiene—Professor H. G. Chapman, M.D.

Tahiti to Botany Bay—Mr. R. H. Cambage, C.B.E., F.L.S.

Latter Days of Captain Cook and Recent Hawaiian Celebrations—Sir Joseph Carruthers, K.C.M.G., M.L.C., LL.D.

On behalf of the Society the President thanked the speakers for their contributions to the evening.

DECEMBER 5, 1928.

The four hundred and eighty-third General Monthly Meeting was held at the Society's Rooms, 5 Elizabeth Street, Sydney, at 8 p.m.

Mr. W. Poole, President, in the Chair.

Twenty-six members and two visitors (Professor Goddard of the University of Queensland and Mr. J. H. Steers of the University of Cambridge) were present.

The Minutes of the general monthly meetings of 3rd October and 7th November, 1928, were read and confirmed.

The President spoke of the loss sustained through the death of Mr. R. H. Cambage. He gave a short outline of the part Mr. Cambage had taken in the management of the Royal Society and asked the meeting to endorse the following motion carried at the Council meeting on 28th November.

"That the Council of the Royal Society of New South Wales records its high appreciation of the valuable services rendered to the Society for over twenty years as President, Honorary Secretary and member of Council by the late Richard Hind Cambage, Vice-President, who died on November 28th, 1928. His untiring zeal for the welfare of the Society, his continuous efforts to increase its utility and his splendid gifts of organisation have been of inestimable worth to the Council in the direction

of affairs. His equable spirit, his generous mind and his warm nature endeared him personally to all who laboured with him as friend and colleague. His wide understanding of the relations between plants and their surroundings, his genius for observation, his rare botanical skill, have enriched the science of botany in Australia and added lustre to his fame."

This was done, those present standing in silence.

The certificate of the following candidate was read for the first time:—Henry George Pyke, Chemical Testing Assistant of the New South Wales Government Tramways.

The President nominated Mr. E. C. Andrews to preside at the ballot box, and members elected Messrs. R. W. Tannahill and H. G. Farnsworth to act as scrutineers, when the following gentleman, whose certificate had been read a second time, was duly elected an ordinary member of the Society:—Victor Marcus Coppleson.

THE FOLLOWING PAPERS WERE READ:

1. "The Chemistry of the Exudation from the Wood of *Pentaspodon Motleyii*," by A. R. Penfold, F.A.C.I., F.C.S., and F. R. Morrison, A.A.C.I., F.C.S.

2. "The Essential Oil from a Boronia in the Pinnate Section from Fraser Island, Queensland," by A. R. Penfold, F.A.C.I., F.C.S.

3. "An Examination of Defective Oregon (*Pseudotsuga Taxifolia*)," by M. B. Welch, B.Sc., A.I.C.

Remarks were made by the President.

4. "On the Probable Tertiary Age of Certain New South Wales Soils," by Assist.-Prof. W. R. Browne, D.Sc.

5. "The Essential Oil of a new species of Anemone leaf Boronia, rich in Ocimene," by A. R. Penfold, F.A.C.I., F.C.S.

6. "On some Aspects of Differential Erosion," by Assist.-Prof. W. R. Browne, D.Sc.
7. "Further notes on the Genus Boronia," by E. Cheel.
8. "Alkalization and other Deuteric Phenomena in the Saddleback Trachybasalt at Port Kembla," by Assist.-Prof. W. R. Browne, D.Sc., and H. P. White, F.C.S.
9. "Notes on some Organisms of Tomato Pulp," by G. L. Windred (communicated by Gilbert Wright).
10. "Notes on some Australian Timbers of the *Monimiaceae*," by M. B. Welch, B.Sc., A.I.C.
11. "Note on a Fossil Shrimp from the Hawkesbury Sandstones," by Charles Chilton, M.A., D.Sc., M.B. (communicated by W. S. Dun).

LECTURETTE:

"Recent Researches on the effects of radiations used in the treatment of cancers," by Prof. H. G. Chapman, M.D.

Remarks were made by Mr. A. D. Olle and the President.

EXHIBIT:

The Prize Design of "Science House."

GEOLOGICAL SECTION.

ABSTRACT OF THE PROCEEDINGS

OF THE

GEOLOGICAL SECTION.

Annual Meeting, April 20, 1928.

Professor Cotton was in the chair, and twelve members and nine visitors were present.

The Chairman welcomed back Mr. E. C. Andrews from his trip abroad.

Mr. C. A. Sussmilch was congratulated upon his appointment as Principal of the East Sydney Technical College, and Assist.-Supt. of Technical Education.

Mr. E. C. Andrews and Mr. G. D. Osborne were elected Chairman and Hon. Secretary respectively for the year.

EXHIBITS:

1. By Dr. A. B. Walkom: Fossil plant from Brookvale Quarry, which was probably *Neocalamites,* showing strong nodal divisions.
2. By Mr. L. L. Waterhouse: (a) Hawkesbury sandstone from North Curl Curl Head containing shale fragments, which were sometimes ferruginous, and possessed jointing independent of the including sandstone.

   (b) Specimens of cemented ilmenitic sand and associated fulgurites, from the same locality.

Mr. E. C. Andrews gave a brief account of his recent visits to some of the American Universities, and also of his experiences in Canada, while attending the Second Empire Mining Congress at Montreal.

May 18, 1928.

Mr. Andrews was in the chair, and ten members and four visitors were present.

The following resolutions were carried unanimously, on the motion of Dr. Browne and Mr. Poole:

That this Section desires to place on record its appreciation of the long and valuable services rendered by Mr. G. W. Card, A.R.S.M., as Curator of the Mining Museum over many years, to geological science in N.S.W.

That the members desire to acknowledge gratefully their indebtedness to Mr. Card for so constantly sending exhibits to the meetings of the Section, thereby increasing very materially the interest and value of these meetings.

That the Hon. Secretary be instructed to convey the foregoing resolutions to Mr. Card, with the cordial greetings and good wishes of the Section.

EXHIBITS:

1. By Mr. Morrison: (a) Crystals of tantalite from Western Australia; (b) Perthite from Broken Hill; (c) Photographs of prismatised sandstone occurring at the Giant's Castle, Lane Cove, and in a quarry $1\frac{1}{2}$ miles south of Gordon.

2. By Dr. W. R. Browne: Specimens of decomposed Tertiary basalt from Wingello, N.S.W. These occur in association with basalt, and possess a characteristic violet colour, a feature recorded in connection with basalt in similar association in other parts of the world.

3. By Mr. H. G. Raggatt: Specimen of analcite-dolerite from a sill of probable Tertiary age which intrudes the Upper Coal Measures at Broke, N.S.W.

4. By Mr. C. A. Sussmilch: (a) Suite of specimens from the Albury district, comprising phyllites, schists, granite with schist inclusions, and pegmatite; (b) Granite from the Hume Reservoir Area.

5. By Mr. A. J. Shearsby: Photographs of cylindrical concretionary formation in the sandstone at Mosman.

A discussion upon "The Occurrence of Bands in Coal Seams, and their bearing on the origin of Coal, with special reference to the Newcastle Coal Field," was opened by Mr. L. J. Jones.

Mr. Jones described clearly the occurrence of well-defined bands in the Borehole Seam in the Newcastle-Wallsend district, emphasising the uniformity of thickness of the bands and the sharp boundaries existing between band and coal. He pointed out that the coal was often laminated, and concluded that all the phenomena observed could be explained only by assuming the coal to have originated by deposition of plant-material transported from some source, the bands then being due to special variations in the conditions of deposition.

Professor Browne commented upon the features which had been stressed by Mr. Jones, and thought the textural variation to be seen in the bands might be the result of the showering of tuff upon coal-measure swamps, but considered that careful microscopic examination was necessary before any conclusion could be reached.

Messrs. Andrews, Harper, Morrison, Raggatt, Sussmilch and Osborne made brief contributions, and it was decided to continue the discussion at the next meeting.

June 29, 1928.

Mr. Andrews was in the chair, and thirteen members and three visitors were present.

It was unanimously resolved to send a letter of sympathy to Mr. W. S. Dun on account of his severe illness.

EXHIBITS:

1. By Dr. W. R. Browne: (a) Specimens of tuff from the Permo-Carboniferous marine beds at Twin Trig., near Tallong, N.S.W., and from Bundanoon; (b) Siderite in mamillary form with fibrous radial structure, from basalt, Lismore, N.S.W.; (c) Specimen of common opal collected about 60 miles south of Dubbo.

2. By Mr. L. L. Waterhouse: (a) Two specimens of opal-bearing jasperoid quartzite from Tallong; (b) Specimens of bismuth-ore from a contact zone between

granite and limestone, at Riddell's Mine, Duckmaloi, near Oberon, N.S.W.

3. By Mr. M. Morrison: Specimen of bright shale, not unlike bitumen, which by analysis appears to be a high-grade cannel coal. Locality, Newnes, N.S.W.; (b) Coals with bands from the Clarence River Series (Mesozoic).
4. By Mr. H. F. Whitworth: Celestine occurring in the gypsum beds of Ivanhoe, N.S.W.
5. By Mr. Clark: Waterworn kerosene shale from Morna Point, also photographs of raised beach at same place.
6. By Dr. A. B. Walkom: Two coal balls, of calcareous concretionary character, containing well-preserved plant-fossils, one ball from Belgium, and the other from the Lancashire Coal Field; (b) Coorongite from Kangaroo I., S.A.; (c) Fossil plants from Yalwal, N.S.W., viz.: *Protolepidodendron yalwalense, Protolepidodendron lineare,* and *Lepidodendron clarkei (?).* The study of these confirmed the assigning, by Mr. Andrews, to the Yalwal beds of a Devonian age.
7. By Mr. G. D. Osborne: Specimens of basalt and basaltic pumice from the Toowoomba district. Also, in collaboration with Mr. Waterhouse, photographs of the Toowoomba Quarry, which has been reserved in the interests of science.

The discussion commenced at the previous meeting was continued.

Mr. Harper described some of the features in the seams of the Southern Coal Field, and concluded that these were evidence of the accumulation of coaly material in swamps in which there were channels of drainage alternating with sand bars built up by the wind.

Dr. Browne reported having examined some of the material of the bands microscopically, but found it very difficult to make much out of the slides. He felt sure that if the coal were transported, then there would be a certain amount of detrital material present in the coal, apart from the distinct bands.

Mr. Morrison reported the occurrence of a band in the Western Coal Field, with a thickness of one inch, which was persistent over an area 50 miles in extent.

Mr. Sussmilch said that the association of kerosene shale, which had developed *in situ*, with the coal seams was a point in favour of the "Growth-in situ" theory.

Dr. Walkom thought the band referred to by Mr. Morrison could not have originated by any of the ordinary methods of mechanical sedimentation. He explained that the advanced decay of woody tissue of plants produced a series of ulmins, leaving unaltered spores, etc. Thus in a deposit of coal produced by the accumulation of transported material, one would expect to find a smaller percentage of spores than in the case of the plants decomposing *in situ.*

Mr. Waterhouse mentioned the possibility of the bands developing at times when conditions were special, caused by the incursion of the sea into the coal swamp areas.

Professor Cotton, Messrs. Andrews, Poole, Whitworth, and Dr. Brennand also spoke briefly, and Mr. Jones replied to many points raised in the whole discussion.

July 27, 1928.

Mr. Andrews was in the chair, and eleven members and six visitors were present.

The Chairman welcomed Mr. Letchworth English, Mineralogist from the F. A. Ward Foundation of Natural Science in the University of Rochester, U.S.A.

EXHIBITS:

1. By Mr. M. Morrison: (a) Spotted and banded sedimentary rock from Kimberley, W.A.; (b) Crystal of rhodonite, in association with sulphide ore, from Broken Hill, N.S.W.

2. By Mr. H. G. Raggatt: Schists, probably andalusite-bearing, from Anembo, 15 miles south of Captain's Flat, N.S.W.

3. By Dr. A. B. Walkom: (a) Specimens of *Lepidodendron* collected by Dr. Woolnough from 65 miles south of Bermagui. These have affinities with *Protolepidodendron* and may be from an extension of the Yalwal beds;

(b) Small branch of *Lepidodendron* with leaves attached, collected by Mr. Sussmilch, at Arden Hall, Upper Hunter District, N.S.W.; (c) Specimen of unusual *Lepidodendron* from the Karuah River District.

4. By Mr. G. D. Osborne: *Conularia* from the Upper Marine Series at Branxton, N.S.W.

Assistant-Professor Browne opened a discussion on "Tertiary Igneous Activity in N.S.W."

DISCUSSION:

Dr. Browne dealt with the rocks in a comprehensive review, discussing their distribution, petrology and tectonic relationships, and instituted comparisons and contrasts with Tertiary rocks in other parts of Australia and elsewhere. He pointed out that there was a wide area covered by the rocks, which occurred as extrusions and intrusions, showing a great variety of type. Thus there were rocks ranging from ultrabasic to acid, with much variation in texture. The basalts are all olivine-bearing, and nearly all contain analcite, or nepheline or a zeolite. They are distinctly alkaline, the intrusions being, in general, more alkaline than the extrusions. The silica percentage ranges from 38 per cent. to 74 per cent., reaching the latter figure in the rhyolites. A consideration of the norms of the analysed rocks showed that only four of the basalts were calcic. Some of the intrusive masses are members of the quartz-dolerite group. The basalts are not related closely to the Plateau basalts, in the sense given to that term by Washington. The relations of the N.S.W. rocks to the Tertiary igneous rocks of Victoria and of Queensland are not very well known.

The absence of major intrusions does not imply necessarily that such do not exist at deeper levels of the crust.

Mr. C. A. Sussmilch pointed out that on physiographic grounds the strongly alkaline lavas were to be considered younger than the two main groups of basic lavas.

Professor Cotton spoke regarding the relationship between the distribution of the Tertiary lavas and the tectonic structures of the eastern margin of the continent, particularly between Central Eastern Queensland and South-eastern New South Wales. He also referred to some Tertiary necks in the New England district.

Mr. Osborne discussed the relations between the trends of the dykes and the directions of jointing and faulting in the Sydney-Blue Mountains region.

The discussion was then adjourned till the next meeting.

August 31, 1928.

Mr. Andrews was in the chair, and eight members and one visitor were present.

EXHIBITS:

1. By Mr. T. Hodge Smith: (a) Lithiophilite, a phosphate of lithium and manganese; also a new mineral, hydrothorite, a hydrous silicate of thorium, and in addition the caesium-beryl, vorobyevite: locality, Wodgina, W.A. (b) Galena with hedenbergite, from Broken Hill.

The discussion on "Tertiary Igneous Activity in N.S.W." was continued.

Dr. Walkom pointed out that the division of the basalts into "Older" and "Newer" received no support from a consideration of the floras of the "deep leads." He also drew attention to the occurrence of the alkaline masses of the Glass House Mountains, to the east of the main line of uplift in Eastern Australia.

Mr. Smith referred to the Kyogle district where the volcanic succession seemed to fit in with Prof. Richards' classification of the Queensland flows. He also suggested correlation of some of the Tertiary flows by means of the deuteric minerals present.

Mr. Andrews drew attention to the relations between the distribution of the flows and the margins of the old stable blocks of Palaeozoic rocks. It seemed as if the leucite lavas were poured out on the old blocks while folding around the margin of these went on, and while the areas of crumpling were characterised by volcanic vents giving forth ash and lava. The plateau basalts flooded the old stable blocks.

Professor Browne replied to many points raised, and short contributions were made by Prof. Cotton and Mr. Poole.

September 28, 1928.

Mr. Andrews was in the chair, and ten members and two visitors were present.

The Secretary announced a proposed excursion to Norton's Basin on Saturday, October 20th, 1928.

EXHIBITS:

1. By Sir Edgeworth David: Casts of Eurypterid remains from the Adelaide (Lipalian) Series of Pre-Cambrian age. The remains were of the nature of claws and spines, probably representatives of the *Merostomata.*

2. By Mr. L. L. Waterhouse: A series of specimens from the Bald Hills, Bathurst, illustrating the occurrence of flows of basalt overlying Tertiary drift, which in turn lies on decomposed granite, the last-named no doubt having been weathered in Tertiary times.

3. By Mr. G. D. Osborne: (a) Specimens of volcanic tuff from the Narrabeen Series at Long Reef, N.S.W.; (b) Specimens of sandstone, altered sandstone with much coaly material, and sandstone with pronounced slickensides, from the neighbourhood of the Basin volcanic rock, Nepean River.

Professor L. A. Cotton addressed the section on "Causes of Diastrophism and their Status in Current Geological Thought."

This lecture was along the lines of the Presidential Address delivered by Professor Cotton to Section C of the A.A.A.S. at the Hobart (1928) Meeting, which address has been published in the report of that meeting, pp. 171-218.

The address was discussed by Sir Edgeworth David and Mr. Osborne, and a reply made by Dr. Cotton.

October 26, 1928.

Mr. Andrews was in the chair, and nine members were present.

A letter from Mr. G. W. Card returning thanks and greetings for the letter conveying the resolutions of May 18, was read.

The Secretary reported that a very successful excursion had been held on Saturday, October 20, to the Basin, near Mulgoa. About thirty-five members and friends attended, and the trip was made in cars kindly made available by some of the members. The physiography and general geology of the very interesting region near the Basin were studied.

NOTES AND EXHIBITS:

Mr. Andrews gave a brief report upon a recent trip which he and the members of the Artesian Water Conference had taken in the Broken Hill-Grey Range-Tibbooburra region. He exhibited many specimens to illustrate his remarks, including a scratched boulder from (?) Lower Cretaceous Glacial beds.

2. By Sir Edgeworth David: Casts of appendages of Eurypterids from limestone in the Adelaide Series. Also, on behalf of Miss D. R. Taylor: (a) Crustacean remains from the Carboniferous Calciferous sandstone of Gullane, Scotland; (b) Beautifully preserved ammonite from the Oolite of Radstock, England.

3. By Mr. Poole: Panoramic photographs of the Basin Area, Nepean River, showing features examined on the excursion held on October 20.

4. By Mr. Osborne: (a) Crystal of quartz, showing "shadow-crystal" nucleus; (b) Composite crystal of quartz showing successive growth-zones; (c) Coral sand-rock from Norfolk Island sent by Mr. Card.

A committee consisting of Prof. Cotton, Dr. Walkom and Messrs. Dun and Shearsby was appointed to enquire into the matter of the delay in the reservation of the Hatton's Corner site.

PAPERS:

Two papers of mineralogical interest from current literature were presented in abstract, as follows:

1. "The Geology of the Platinum Metals," by J. H. L. Vogt. Presented in abstract by Mr. G. D. Osborne, and discussed by Sir Edgeworth David and Mr. Andrews.

2. "The Natural History of the Silica Minerals," by Austin F. Rogers. Presented by Mr. T. Hodge Smith and discussed by Sir Edgeworth David and Mr. Osborne.

November 30, 1928.

Mr. Andrews was in the chair and eight members and two visitors were present.

The Chairman referred to the sudden death of Mr. R. H. Cambage, which had occurred three days previously, and the following resolution was carried in silence:

> "That the members of the Geological Section desire to record their deep sense of the loss sustained by the death of their beloved friend and colleague, Mr. R. H. Cambage, and extend to the bereaved relatives their heartfelt sympathy."

A cordial welcome was extended to Mr. F. G. Forman, of Western Australia, who exhibited two samples of natural oil obtained by him from seepages in the Kerema District, Gulf Division, Papua.

Mr. E. C. Andrews initiated a discussion upon "The Mechanics of Igneous Intrusion."

He gave a brief summary of the outstanding features of the earth's surface as a foundation for an enquiry into the relation of intrusions and extrusions of magma through the earth's crust. He drew attention to the lines of mountain ranges on the earth and their relation to volcanoes and bathylites. Mr. Andrews considered that the mountain belts were essentially geanticlinal units in a series of earth undulations or waves, and explained his view of the migration of magma during the activity of these undulations.

He believed that the intrusive igneous rocks came into their places of crystallisation by a process akin to "sweating" through the country rocks. He stressed the

facts that most intrusions showed no feeders, and he thought that the characteristics of form and origin of ore bodies could be a guide to the study of intrusives.

Dr. Browne did not see eye to eye with the Chairman in regard to the matter of the analogy between ore bodies and igneous masses. He considered that the former were very specialised units whose behaviour was probably quite different from that of bathylites. He found difficulty in understanding the mechanism of the undulations or waves which Mr. Andrews had described.

Mr. Osborne gave a separate contribution to the discussion by presenting a summary of the views of some of the geologists of the British Survey regarding the "cauldron-subsidence" phenomena to be observed at Glencoe and in N.E. Ireland.

Mr. Andrews replied to some points raised, and the discussion was adjourned until the next meeting.

SECTION OF INDUSTRY.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF INDUSTRY.

Officers—Chairman: A. D. Olle, F.C.S.; *Honorary Secretary*: H. V. Bettley-Cooke.

As in 1927, the activities of the Section consisted of visits to industrial establishments.

In all cases manufacturers gave a cordial welcome to members and went to considerable trouble in explaining their processes and in preparing exhibits.

The following visits were paid:—

May 15th, 1928—British-Australian Lead Manufacturer's Works, Cabarita.

June 19th, 1928—Goodyear Tyre and Rubber Co. (Australia) Ltd.

July 17th, 1928—Nestle's Chocolate Factory, Abbotsford.

August 21st, 1928—General Motors (Australia) Pty. Ltd., Marrickville.

September 18th, 1928—Australian Glass Manufacturers Co. Ltd., Dowling Street, Waterloo.

October 9th, 1928—Messrs. Elliott Bros. Chemical Works, Balmain.

November 27th, 1928—Messrs. Parke Davis & Company Works, Rosebery.

December 11th, 1928—Sydney Harbour Trust Operations on the Harbour.

SECTION OF PHYSICAL SCIENCE.

ABSTRACT OF PROCEEDINGS

OF THE SECTION OF

PHYSICAL SCIENCE.

Seven meetings were held during the year. The average attendance was fifteen. At the May meeting the following officers were elected:

Chairman—Assoc. Professor Wellish, M.A.

Honorary Secretary—G. H. Briggs, B.Sc., Ph.D., F.Inst.P.

Committee—Associate Professor Bailey, M.A., Ph.D., F.Inst.P., Major E. H. Booth, M.C., B.Sc., F.Inst.P., Professor Madsen, D.Sc., Rev. Father Pigot, S.J., B.A., M.B., Mr. J. J. Richardson, A.M.I.E.E., Professor Vonwiller, B.Sc., F.Inst.P.

April 18th, 1927.

Professor Bailey in the chair.

Mr. J. C. Jaeger read a paper on "The Motion of Electrons in Pentane."

A sketch of the theory and experimental procedure involved in Professor Bailey's original 3-slit apparatus was given. In the work on pentane, readings were taken in this apparatus at values of z/p of 2.5, 5, 10, 20, 40 for the determination of k and α. Experiments were then made at the same values of z/p in a Townsend diffusion apparatus for the determination of W. The values of α are low and decrease with increasing z/p as in air, and the probability h shows a similar rapid decrease at low values of z/p. The k, z/p curve is nearly linear and of compara-

tively small slope, while the values of W show a rapid initial rise. These peculiarities cause a maximum of λ at a low value of z/p. The same effect is shown by the other polyatomic gases yet investigated CO_2, NO_2 and C_2H_4, to the last of which pentane is specially similar. It was suggested that this effect is connected with the formation of ions.

Mr. J. D. McGee, M.Sc., read a paper on "The Attachment of Electrons to Molecules of Ammonia."

An outline of the theory of a three slit apparatus designed by Professor Bailey was given. In this apparatus the distance between the plates can be varied from 2 to 4 cms. Experiments with ammonia were made in order to check the previous work of Professor Bailey and Mr. Higgs using the older apparatus. Hydrogen was found in the gas which they had used. With a fresh supply of pure ammonia observations were made from $z/p = 7$ to $z/p = 32$. and the values of a and k determined. It was found that k increased very rapidly from $k = 3$ at $z/p = 7$ to $k = 60$ at $z/p = 14$. Over the same range a/p also increased rapidly from 0.006 to 0.125.

From these results it was deduced that unless the drift velocity of the electrons decreased rapidly over this range, the probability of the attachment of an electron to a molecule of ammonia must increase over this range. Hence it appears that the probability of attachment is not independent of the velocity of the electron as was assumed by Loeb.

May 16th, 1927.

Professor Wellish in the chair.

An address was given by Professor Madsen, D.Sc. He discussed—

(1) the research in wireless being carried out in Great Britain by the Radio Research Board;

(2) work on geophysical prospecting by Eve, Edge and Bieler, and

(3) legal definitions of standards in various countries.

Professor V. A. Bailey, M.A., Ph.D., F.Inst.P., described a rapid method for determining the pulsation Ω and damping coefficient of free oscillations in any electric network containing inductances, resistances and capacities. At any part of the network an alternating sinoidal e.m.f. of pulsation w and zero amplitude is introduced and the equations for the currents in different parts of the network are written down with the assistance of Kirchhoff's rules, but replacing the operator d/dt by wj as in the method of complex operators.

The condition that these currents be different from zero, as they must in the case of free oscillations, is equivalent to an equation $\Delta\ (wj) = 0$ where Δ is the determinant formed by the coefficients of the currents in the above equations.

Each root w of this equation then gives the Ω and μ of one of the free oscillations through the relation $w = \Omega + \mu j$.

In many special cases the above process is equivalent to either of the following:—

(1) If the network can be regarded as a single circuit with impedence operator z; then the equation in w will be $z = 0$.

(2) If the admittance operator y between any two points in the network can be determined the equation in w will be given by $y = 0$.

The use and value of the method was illustrated by application to several standard cases.

June 20th.

Professor Wellish in the chair.

Major E. H. Booth, B.Sc., F.Inst.P., gave an address on "Geophysical Methods of Prospecting."

July 18th.

Professor Wellish in the chair.

Mrs. G. H. Briggs gave an address on "Recent Developments of Quantum Theory."

September 19th.

Professor Wellish in the chair.

Mr. W. G. Baker, B.Sc., B.E., read a paper on "Radio Broadcast Transmission in the Neighbourhood of Sydney."

Measurements of signal strength were made by L. S. C. Tippett, B.Sc., B.E., and W. G. Baker, B.Sc., B.E., by receiving the signals on a loop interval tuned by a variable condenser. The voltage in the loop was measured by a Moulin type thermionic voltmeter. The observations were restricted to a distance of about 20 miles from the station 2FC and were made along seven directions radiating from the station, open spaces being chosen at each point.

The results, illustrated by a polar diagram, show in general a much more rapid fall off to the north, over the wooded country, than to the south. The absorption coefficient was measured in each direction and by making use of Sommerfeld's theory the conductivity of the ground was deduced.

By integrating the power radiated over a hemisphere and taking into account the absorption it was deduced that 82% of the 5000 watts input to the station is radiated.

October 17th.

The business of the meeting was a demonstration of experiments with diodes and triodes by Professor Bailey.

JOURNAL

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1929

(INCORPORATED 1881.)

VOL. LXIII.

EDITED BY

THE HONORARY SECRETARIES.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

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VOLUME LXIII.

NOTICE.

The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors should submit their papers in typescript and in a condition ready for printing. All physico-chemical symbols and mathematical formulæ should be so clearly written that the compositor should find no difficulty in reading the manuscript. Sectional headings and tabular matter should not be underlined. Pen-illustrations accompanying papers should be made with black Indian ink upon smooth white Bristol board. Lettering and numbers should be such that, when the illustration or graph is reduced to $3\frac{1}{2}$ inches in width, the lettering will be quite legible. On graphs and text figures any lettering may be lightly inserted in pencil. Microphotographs should be rectangular rather than circular, to obviate too great a reduction. The size of a full page plate in the Journal is $4 \times 6\frac{1}{4}$ inches, and the general reduction of illustrations to this limit should be considered by authors. When drawings, etc., are submitted in a state unsuitable for reproduction, the cost of the preparation of such drawings for the process-block maker must be borne by the author. The cost of colouring plates or maps must also be borne by the author.

FORM OF BEQUEST.

I bequeath the sum of £ to the Royal Society of New South Wales, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

PUBLICATIONS.

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The following publications of the Society, if in print, can be obtained at the Society's Rooms, 15 Castlereagh-street, Sydney.

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

Vols.	I—XI	Transactions of the Royal Society, N.S.W.,					1867—1877,			,,
,,	XII	Journal and Proceedings			,,	,,	1878,	,,	324,	price 10s.6d.
,,	XIII	,,	,,	,,	,,	,,	1879,	,,	255,	,,
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Royal Society of New South Wales.

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C. W. O. TYE

†Deceased 16th July, 1929, succeeded by E .C. ANDREWS, BA.. F.G S.

§Elected Vice-President 28th August, 1929, succeeded by Prof. A. R. RADCLIFFE-BROWN, M.A., F.R.A.I.

*Deceased 22nd May, 1929, succeeded by Prof. T. G. B. OSBORN, D.Sc., F.L.S.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society Journal. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1908		Abbott, George Henry, B.A., M.B., Ch.M., 185 Macquarie-street; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1904		Adams, William John, M.I.Mech.E., 175 Clarence-street.
1898		Alexander, Frank Lee, William-street, Granville.
1905	P 3	Anderson, Charles, M.A., D.Sc. *Edin.*, Director of the Australian Museum, College-street. (President, 1924.) *Vice-President.*
1909	P 9	Andrews, Ernest C., B.A., F.G.S., Hon. Mem. Washington Academy of Sciences, Government Geologist, Department of Mines, Sydney: p.r. 32 Benelong Crescent, Bellevue Hill. *Vice-President.* (President, 1921.)
1919		Aurousseau, Marcel, B.Sc., No. 65A Market-lane, Manly.
1923		Baccarini, Antonio, Doctor in Chemistry (Florence).
1878		Backhouse, His Honour Judge A. P., M.A., 'Melita,' Elizabeth Bay.
1924		Bailey, Victor Albert, M.A., D.Phil., F.Inst.P., Assoc.-Professor of Physics in the University of Sydney.
1919		Baker, Henry Herbert, Watson House, Bligh-street, Sydney.
1894	P 27	Baker, Richard Thomas, The Crescent, Cheltenham.
1926		Bannon, Joseph, B.Sc. Demonstrator in Physics in the University of Sydney; p.r. 'Dunisla,' The Crescent, Homebush.
1919		Bardsley, John Ralph, 'The Pines,' Lea Avenue, Five Dock.
1925		Barker-Woden, Lucien, F.R.G.S., Commonwealth Department of Navigation, William Street, Melbourne.
1908	P 1	Barling, John, L.S., 'St. Adrians,' Raglan-street, Mosman.
1895	P 9	Barraclough, Sir Henry, K.B.E., B.E., M.M.E., M. Inst. C.E., M. I. Mech. E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Dean of the Faculty of Engineering and Professor of Mechanical Engineering in the University of Sydney; p.r. 'Marmion,' Victoria-street, Lewisham.
1929		Baur, Fidel George, M.D., Ophthalmic Surgeon, 213 Macquarie-street, Sydney.
1909	P 2	Benson, William Noel, D.Sc. *Syd.*, B.A. *Cantab.*, F.G.S., Professor of Geology in the University of Otago, Dunedin, N.Z.
1926		Bentivoglio, Sydney Ernest, B.Sc.Agr., c/o University of Sydney.
1919		Bettley-Cooke, Hubert Vernon, 'The Hollies,' Minter-street, Canterbury.
1923		Birks, George Frederick, c/o Potter & Birks, 15 Grosvenor-street

Elected.		
1916		Birrell, Septimus, c/o Margarine Co., Edinburgh Road, Marrickville.
1920		Bishop, Eldred George, 8 Belmont-road, Mosman.
1915		Bishop, John, 24 Bond-street.
1923	P 4	Blakely, William Faris, 'Myola,' Florence-street, Hornsby.
1905		Blakemore, George Henry, 68½ Pitt Street, Sydney.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 'Inglewood,' Florida Road, Palm Beach, Sydney.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1917		Bond, Robert Henry, 'Eastbourne,' 27 Cremorne-road, Cremorne Point.
1926	P 3	Booker, Frederick William, B.Sc., 'Dunkeld,' Nicholson-street, Chatswood.
1920	P 4	Booth, Edgar Harold, M.C., B.Sc., F.Inst.P., Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Bradfield, John Job Crew, D.Sc. Eng., M.E., M. Inst. C.E., M. Inst. E. Aust. Chief Engineer, Metropolitan Railway Construction, Railway Department, Sydney.
1916		Bragg, James Wood, B.A., c/o Gibson, Battle &Co. Ltd.,Kent-st.
1926		Branch, Kenneth James F., Canberra Grammar School, Canberra.
1917		Breakwell, Ernest, B.A., B.Sc., Dept. of Education, Box 33 A, G.P.O., Sydney.
1891		Brennand, Henry J. W., B.A., M.D., Ch.M. *Syd.*, V.D., Surgeon Commander R.A.N. Ret., 223 Macquarie-street; p.r. 73 Milsons Road, Cremorne.
1923		Brereton, Ernest Le Gay, B.Sc.. Lecturer and Demonstrator in Chemistry in the University of Sydney.
1919	P 1	Briggs, George Henry, B.Sc., Ph.D., Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Brough, Patrick, M.A., B.Sc., B.Sc., (Agr.) (Glasgow), Lecturer in Botany in the University of Sydney.
1923		Brown, Herbert, 'Sikoti,' Alexander-street, Collaroy Beach, Sydney.
1906		Brown, James B., St. Andrew's, No 1 Maitland Avenue, East Kew, E. 4, Victoria.
1913	P 16	Browne, William Rowan, D.Sc., Assistant-Professor of Geology in the University of Sydney.
1898		‡Burfitt, W. Fitzmaurice, B.A., M.B., Ch.M. B.Sc., *Syd.*, 'Wyoming,' 175 Macquarie-street, Sydney.
1926		Burkitt, Arthur Neville St. George, M.B., B.Sc., Professor of Anatomy in the University of Sydney.
1919	P 10	Burrows, George Joseph, B.Sc., Lecturer and Demonstrator in Chemistry in the University of Sydney; p.r. Watson-street, Neutral Bay.
1929	P 1	Caley, Gilbert Fatkin, Manager, Glycerine Distillery Co., Ltd., Alexandria; p.r. 'Windyridge,' Park Road, Auburn.
1929		Callaghan, Allan Robert, D.Phil., B.Sc., (*Oxon.*), B.Sc., Agr., Plant Breeder, Experimet Farm, Cowra.
1909		Calvert, Thomas Copley, Assoc.M.Inst.C.E., c/- Dept. of Public Works, Newcastle, N.S.W.
1923		Cameron, Lindsay Duncan, Hilly-street, Mortlake.

Elected		
1907		Campbell, Alfred W., M.D., Ch.M. *Edin.*, 183 Macquarie-street.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.* F.F.A., *Scot.*, 4 Whaling Road, North Sydney.
1920		Carruthers, Sir Joseph Hector, K C.M.G., M.L.C., M.A., *Syd.*, LL.D. *St. Andrews*, 'Highbury,' Waverley.
1903	P 3	Carslaw, Horatio S., M.A., Sc. D., Professor of Mathematics in the University of Sydney.
1913	P 3	Challinor, Richard Westman, F.I.C., F.C.S., Lecturer in Chemistry, Sydney Technical College.
1909	P 2	Chapman, Henry G., M.D., B.S., Director of Cancer Research, University of Sydney. *Hon. Treasurer.*
1913	P 16	Cheel, Edwin, Curator National Herbarium, Botanic Gardens, Sydney.
1925	P 1	Clark, William E., 'Acacia,' Cambridge-street, Epping.
1909	P 20	Cleland, John Burton, M.D., Ch.M., Professor of Pathology in the University of Adelaide. (President 1917.)
1896	P 4	Cook, W. E., M.C.E. *Melb.*, M.Inst.,C.E , Burroway-st., Neutral Bay.
1920		Cooke, Frederick, c/o Meggitt's Limited, 26 King-street.
1913	P 3	Coombs, F. A., F.C.S., Instructor of Leather Dressing and Tanning, Sydney Technical College; p.r. Bannerman Crescent, Rosebery.
1928		Coppleson, Victor Marcus, M.B., Ch.M., F.R.C.S , 225 Macquarie-street, Sydney.
1882		Cornwell, Samuel, J.P., 'Capanesk,' Tyagarah, North Coast.
1919		Cotton, Frank Stanley, B.Sc., Chief Lecturer and Demonstrator in Physiology in the University of Sydney.
1909	P 6	Cotton, Leo Arthur, M.A., D.Sc., Professor of Geology in the University of Sydney. *President.*
1892	P 1	Cowdery, George R., Assoc.M.Inst.C.E , 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 185 Macquarie-st.
1921	P 1	‡Cresswick, John Arthur, 101 Villiers-street, Rockdale.
1927	P 1	Currey, Geoffrey Saunders, 13 Princess-avenue, Homebush.
1925		Curry, Harris Eric Marshall, 8 Lower Wycombe-road, Neutral Bay.
1912		Curtis, Louis Albert, L.S., F.I.S. (N.S.W.), V.D., Room 618, New Government Savings Bank, Castlereagh-street; p.r. No. 1 Mayfair Flats, Macleay-street, Darlinghurst.
1886	P 23	David, Sir Edgeworth, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., Wollaston Medallist, Emeritus Professor of Geology and Physical Geography in the University of Sydney; p.r. 'Coringah,' Burdett-street, Hornsby. (President 1895, 1910.)
1928		Davidson, Walter Charles, General Manager Clyde Engineering Company, Granville.
1890		Dare, Henry Harvey, M.E., M.Inst.C.E , Commissioner, Water Conservation and Irrigation Commission, Union House, George-street.
1919	P 2	de Beuzeville, Wilfrid Alex. Watt, J.P., Beecroft, N.S.W.
1921		Delprat, Guillaume Daniel, C.B.E., 'Keynsham,' Mandeville Crescent, Toorak, Victoria.
1921		Denison, Sir Hugh Robert, K.B.E., 701 Culwulla Chambers, Castlereagh-street.

Elected		
1894		Dick, James Adam, C.M.G., B.A. *Syd.*, M.D., Ch.M., F.R.C.S. *Edin.*, 'Catfoss,' 59 Belmore Road, Randwick.
1906		Dixson, William, 'Merridong,' Gordon Road, Killara.
1913	P 3	Doherty, William M., F.I.C., F.C.S., Second Government Analyst, 'Jesmond,' George-street, Marrickville.
1928		Donegan, Henry Arthur James, A S.T.C., Chemical Laboratory, Department of Mines, Sydney.
1908	P 6	Dun, William S., Palæontologist, Department of Mines, Sydney. (President 1918.)
1924		Dupain, George Zephirin, A.A.C.I., F.C S., Dupain Institute of Physical Education, Manning Building, Pitt and Hay Streets, Sydney, p.r. 'Symington,' Parramatta Road, Ashfield.
1924		Durham, Joseph, 120 Belmore Road, Randwick.
1923	P 5	Earl, John Campbell, D.Sc. Ph.D., Professor of Organic Chemistry in the University of Sydney.
1919		Earp, The Hon. George Frederick, C.B.E., M.L.C., Australia House, Carrington-street.
1924		Eastaugh, Frederick Alldis, A.R.S.M., F.I.C., Assoc. Professor in Chemistry, Assaying and Metallurgy in the University of Sydney.
1916	P 2	Enright, Walter J., B.A., High-street, West Maitland, N.S.W.
1908		Esdaile, Edward William, 42 Hunter-street.
1887		Faithfull, R. L., M.D., *New York*, L.R.C.P., L.S.A. *Lond.*, c/o Faithfull, Maddocks, Oakes and Baldock, 25 O'Connell-street.
1921		Farnsworth, Henry Gordon, 'Rothsay,' 90 Alt-street, Ashfield.
1910		Farrell, John, A.T.C., *Syd.*, Riverina Flats, 265 Palmer-street, Sydney.
1909	P 7	Fawsitt, Charles Edward, D.Sc. Ph.D., Professor of Chemistry in the University of Sydney. (President 1919).
1922		Ferguson, Andrew.
1927	P 2	Finnemore, Horace, B.Sc., F.I.C., Lecturer in Pharmacy in the University of Sydney.
1923		Fiaschi, Piero, O.B.E., M.D. (Columbia Univ.), D.D.S. (New York), M.R.C.S. (Eng.), L.R.C P (Lond.), 178 Phillip-street.
1920		Fisk, Ernest Thomas, Wireless House, 47 York-street.
1888		Fitzhardinge, His Honour Judge G. H., M.A. 'Red Hill,' Pennant Hills.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.* L.R.C.P. *Edin.*, 'The Astor,' Macquarie-street.
1920		Fortescue, Albert John, 'Benambra,' Loftus-street, Arncliffe.
1905		Foy, Mark, c/o Hydro Office, 133a Pitt-street, Sydney.
1904		Fraser, James, C.M.G., M.Inst.C.E., Chief Commissioner for Railways, Bridge-street.
1925		Friend, Norman Bartlett, 48 Pile-street, Dulwich Hill.
1918		Gallagher, James Laurence, M.A. *Syd.*, 'Akaroa,' Ellesmere Avenue, Hunter's Hill.
1926		Gibson, Alexander James. M.E., M.Inst.C.E , M.I.E.Aust., 906 Culwulla Chambers, Castlereagh-street, Sydney.

Elected		
1921		Godfrey, Gordon Hay, M.A., B.Sc., Lecturer in Physics in the Technical College, Sydney; p.r. 262 Johnston-street, Annandale.
1897		Gould, The Hon. Sir Albert John, K.B., V.D., 'Eynesbury,' Edgecliff.
1922	P 5	Grant, Robert, F.C.S., 24 Edward-street, Woollahra.
1916		Green, Victor Herbert, c/o Australian Fertilizer Pty. Ltd., Macquarie-place, Sydney.
1922	P 2	Greig, William Arthur, Mines Department, Sydney.
1927		Gunn, Reginald Montague Cairns, B.Sc., B.Sc.Agr., M.R.C.V.S. Lecturer in Veterinary Anatomy and Surgery in the University of Sydney.
1923		Gurney, William Butler, B.Sc., Government Entomologist, Department of Agriculture, Sydney.
1880	P 5	Halligan, Gerald H., L.S., F.G.S., "Uplands," Station Street. Pymble.
1912		Hallmann, E. F., B.Sc.. 72 John-street, Petersham.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1919		Hambridge, Frank, Adelaide Steamship Co. Chambers, 22 Bridge-street, Sydney.
1912		Hamilton, Alexander G., 'Tanandra,' Hercules-st., Chatswood.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; p.r. 'Glendowan,' Glenbrook, Blue Mountains. Atlas Building, 8 Spring-st., Sydney. (President 1899, 1908).
1909		Hammond, Walter L., B.Sc., High School, Bathurst.
1916		Hardy, Victor Lawson, 'Tiri Mona,' 11A Gordon-av., Randwick
1905	P 5	Harker, George, D.Sc., F.A.C.I., 57 Junction-street, Summer Hill.
1913	P 1	Harper, Leslie F., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1929		Harris, Samuel Harry, Surgeon, M.D., Ch.M. (*Syd.*), 235 Macquarie-street, Sydney.
1923	P 1	Harrison, Travis Henry, B.Sc.Agr., Lecturer in Entomology and Botany at the Hawkesbury Agricultural College, Richmond; p.r. 17 Hurlstone-avenue, Summer Hill.
1918		Hassan, Alex. Richard Roby.
1929		Hawley, Joseph William, 15 Springdale-road, Killara.
1916		Hay Dalrymple-, Richard T., L.S.; 45 Bay-street, Double Bay
1914		Hector, Alex. Burnet, "Druminard," Greenwich-road, Greenwich.
1916		Henderson, James, 'Dunsfold,' Clanalpine-street, Mosman.
1919		Henriques, Frederick Lester, 208 Clarence-street.
1919	P 2	Henry, Max, D.S.O., B.V.Sc., M.R.C.V.S., Chief Veterinary Surgeon, Dept. Agriculture, Sydney. p.r. 'Coram Cottage,' Essex-street, Epping.
1918		Hindmarsh, Percival, M.A., B.Sc. (Agr.), Teachers' College, The University, Sydney; p.r. 'Lurnea,' Canberra Avenue, Greenwich.
1921	P 2	Hindmarsh, William Lloyd, B.V.Sc., M.R.C.V.S., D.V.H., District Veterinary Officer, Glenfield.
1928		Hirst, George Walter Cansdell, B.Sc., Chief Mechanical Engineer's Office, N.S.W. Govt. Railways, Wilson Street, Redfern

Elected.		
1916		Hoggan, Henry James, A.M.I.M.E., A.M.I.E. (Aust.), Manchester Unity Chambers, 160 Castlereagh-street; p.r. 'Lincluden,' Frederick-street, Rockdale.
1924		Holme, Ernest Rudolph, O.B.E., M.A., Professor of English Language in the University of Sydney.
1901		Holt, Thomas S., 'Amalfi,' Appian Way, Burwood.
1905	P 3	Hooper, George, J.P., F.T.C. *Syd.*, 'Mycumbene,' Nielsen Park, Vaucluse.
1920		Hordern, Anthony, C.B.E., 12 Spring-street, Sydney.
1919		Hoskins, Arthur Sidney, Eskroy Park, Bowenfels.
1919		Hoskins, Cecil Harold, c/o Australian Drug Co., Ltd., Kembla Building, Margaret-street, Sydney.
1919		Houston, Ralph Liddle, No. 1 Lincluden Gardens, Fairfax-rd., Double Bay.
1913		Hudson, G. Inglis, J.P., F.C.S. 180 Arden-st., Coogee.
1920		Hulle, Edward William, Commonwealth Bank of Australia.
1923	P 2	Hynes, Harold John, M.Sc., B.Sc., Agr., Senior Asst. Biologist, Department of Agriculture, Sydney.
1927		Inglis, William Keith, M.D., Ch.M., Lecturer in Pathology in the University of Sydney; p.r. 34 Wolseley-street, Drummoyne.
1923		Ingram, William Wilson, M.C., M.D., Ch.B., 185 Macquarie-st., Sydney.
1922		Jacobs, Ernest Godfried, 'Cambria,' 106 Bland-street, Ashfield.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Chief Inspector of Mines, Department of Mines, Sydney.
1929		Jeffrey, Robert Ewen, A.A.C.I., Managing Director, Bardsley's Ltd.; p.r. 9 Greycliffe-avenue, Vaucluse.
1925		Jenkins, Charles Adrian, B.E., B.Sc., 2 Ramsgate Avenue, Bondi Beach.
1917		Jenkins, Richard Ford, Engineer for Boring, Irrigation Commission, 6 Union-street, Mosman.
1918		John, Morgan Jones, M.I.Mech.E., A.M.I.E.E. *Lond.*, M.I.E. *Aust.*, M.I.M. *Aust.*, Atlas Building, 8 Spring-street; p.r. Olphert Avenue, Vaucluse.
1909	P 15	Johnston, Thomas Harvey, M.A., D.Sc., F.L.S., C.M.Z.S., Professor of Zoology in the University of Adelaide.
1924		Jones, Leo Joseph, Geological Surveyor, Department of Mines, Sydney.
1911		Julius, George A., Sir, Kt., B.Sc., M.E., M.I.Mech.E., Culwulla Chambers, Castlereagh-street, Sydney. *Vice-President.*
1924		Kenny, Edward Joseph, Field Assistant, Department of Mines, Sydney; p.r. 45 Robert-street, Marrickville.
1887		Kent, Harry C., M.A., F.R.I.B.A., Dibbs' Chambers, 58 Pitt-st.
1919	P 3	Kesteven, Hereward Leighton, M.D., Ch.M., D.Sc., Bulladelah, New South Wales.
1896		King, Kelso, Sir, K.B., 117 Pitt-street, Sydney.

Elected		
1923		Kinghorn, James Roy, Australian Museum, Sydney.
1920		Kirchner, William John, B.Sc., "Wanawong," Thornleigh-road, Beecroft.
1919		Kirk, Robert Newby, 25 O'Connell-street.
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1924		Leech, Thomas David James, B.Sc., *Syd.*, 'Orontes,' Clarke-st., Granville.
1920		Le Souef, Albert Sherbourne, Taronga Park, Mosman.
1916		L'Estrange, Walter William, 7 Church-street, Ashfield.
1909		Leverrier, Frank, B.A., B.Sc., K.C., Wentworth Road, Vaucluse.
1883		Lingen, J. T., M.A. *Cantab.*, K.C., c/o Union Club, Bligh-st.
1929	P 2	Lions, Francis, B.Sc., Ph.D., Lecturer in Organic Chemistry in the University of Sydney.
1906		Loney, Charles Augustus Luxton, M.Am.Soc.Refr E., Equitable Building, George-street.
1924		Love, David Horace, Beauchamp Avenue, Chatswood.
1927		Love, William Henry, B.Sc., "Lumeah," 9 Miller-street, Haberfield.
1884		MacCormick, Sir Alexander, K.C.M.G., M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street.
1923		Mackay, Iven Giffard, C.M.G., D.S.O., B.A., Student Adviser and Secretary of Appointments Board, The University, Sydney.
1921		McDonald, Alexander Hugh Earle, Superintendent of Agriculture, Department of Agriculture, Sydney.
1903		McDonald, Robert, J.P., L.S., Pastoral Chambers, O'Connell-st; p.r. 'Lowlands,' William-street, Double Bay.
1919		McGeachie, Duncan, M.I.M.E., M.I.E. (Aust.), M.I.M.M. (Aust.), 'Craig Royston,' Toronto, Lake Macquarie.
1906		McIntosh, Arthur Marshall, 'Moy Lodge,' Hill-st., Roseville.
1891	P 2	McKay, R. T., L.S., M.Inst.C.E., Commissioner, Sydney Harbour Trust, Circular Quay.
1922		McLuckie, John, M.A., B.Sc., (*Glasgow*), D.Sc., (*Syd.*), Assistant-Professor of Botany in the University of Sydney.
1927		McMaster, Frederick Duncan, "Dalkeith," Cassilis.
1916		McQuiggin, Harold G., M.B., Ch.M., B.Sc., Lecturer and Demonstrator in Physiology in the University of Sydney; p.r. 'Berolyn,' Beaufort-street, Croydon.
1909		Madsen, John Percival Vissing, D.Sc., B.E., Professor of Electrical Engineering in the University of Sydney.
1924		Mance, Frederick Stapleton, Under Secretary for Mines, Mines Department Sydney; p.r. 'Binbah,' Lucretia Avenue, Longueville.
1880	P 1	Manfred, Edmund C., Belmore-square, Goulburn.

Elected.		
1920	P 1	Mann, Cecil William, 41 Jenkin-street, Chatswood.
1920		Mann, James Elliott Furneaux, Barrister at Law, c/o H. Southerden, Esq., Box 1646 J.J., G.P.O., Sydney.
1908		Marshall, Frank, C.M.G., B.D.S., 143 Macquarie-street.
1914		Martin, A. H., Technical College, Sydney.
1929		Matheson, Alexander James, Teacher, The High School, Bathurst.
1926		Mathews, Hamilton Bartlett, B.A. *Syd.*, Surveyor General of N.S W., Department of Lands, Sydney.
1912		Meldrum, Henry John, B.A., B.Sc. 'Craig Roy,' Sydney Road, Manly.
1929		Mellor, David Paver, Assistant Lecturer in Chemistry in the University of Sydney; p.r. Flat 8, 'Deanville,' Milson-road, Cremorne.
1922		Mills, Arthur Edward, M.B., Ch.M., Dean of the Faculty of Medicine, Professor of Medicine in the University of Sydney; p.r. 143 Macquarie-street.
1928		Micheli, Louis Ivan, Ph.D., Colonial Sugar Refining Co., Pyrmont.
1926		Mitchell, Ernest Marklow, 106 Harrow Road, Rockdale
1879		Moore, Frederick H., Union Club, Sydney.
1922	P 15	Morrison, Frank Richard, A.A.C.I., F.C.S., Assistant Chemist, Technological Museum, Sydney; p.r. Brae-st., Waverley.
1924		Morrison, Malcolm, Department of Mines, Sydney.
1879		Mullins, John Lane, M.L.C., M.A. *Syd.*, 'Killountan,' Double Bay.
1915		Murphy, R. K., Dr. Ing., Chem. Eng., Lecturer in Chemistry Technical College, Sydney.
1923	P 2	Murray, Jack Keith, B.A., B.Sc. (Agr.), Principal, Queensland Agricultural College, Gatton, Queensland.
1893	P 4	Nangle, James, O.B.E., F.R.A.S., Superintendent of Technical Education, The Technical College, Sydney; Government Astronomer, The Observatory, Sydney. (President 1920.)
1917		Nash, Norman C., 'Ruanora,' King's Road, Vaucluse.
1924		Nickoll, Harvey, L.R.C.P., L.R.C.S., Barham, via Mudgee, N.S.W.
1891		‡Noble, Edward George, L.S., 8 Louisa Road, Balmain.
1920	P 2	Noble, Robert Jackson, M.Sc., B.Sc.Agr., Ph.D., Biologist, Dept. of Agriculture, Sydney; p.r. 'Casa Loma,' Shell Cove Road, Neutral Bay. *Hon. Secretary.*
1903		‡Old, Richard, 'Waverton,' Bay Road, North Sydney.
1921		Olding, George Henry, 'Werriwee,' Wright's Road, Drummoyne.
1913		Ollé, A. D., F.C.S., 'Kareema,' Charlotte-street, Ashfield.
1891		Osborn, A. F., Assoc.M.Inst.C.E., Water Supply Branch, Sydney; p.r. 'Waugoola,' Fern-street Pymble.
1928		Osborn, Theodore George Bentley, D.Sc., F.L.S., Professor of Botany in the University of Sydney.

Elected		
1921	P 3	Osborne, George Davenport, D.SC., Lecturer and Demonstrator in Geology in the University of Sydney; p.r. 'Belle-Vue,' Kembla-st., Arncliffe.
1921	P 1	Parkes, Varney, Conjola, South Coast.
1928		Parsons, Stanley William Enos, Analyst and Inspector, N.S.W. Explosive Department, p.r. Shepherd Road, Artarmon.
1920	P 52	Penfold, Arthur Ramon, F.C.S., Curator and Economic Chemist, Technological Museum, Harris-street, Ultimo.
1879	P 8	Pittman, Edward F., Assoc.R.S.M. L.S., 'The Oaks,' Park-street, South Yarra, Melbourne.
1881		Poate, Frederick, F.R.A.S., L.S., 'Clanfield,' 50 Penkivil-street, Bondi.
1919		Poate, Hugh Raymond Guy, M.B., Ch. M. *Syd.*, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 225 Macquarie-street.
1896		Pope, Roland James, B.A., *Syd.*, M.D., Ch.M., F.R.C.S.. *Edin.*, 185 Macquarie-street.
1921	P 2	Powell, Charles Wilfrid Roberts, A.I.C., c/o Colonial Sugar Refining Co., O'Connell-street.
1918		Powell, John, 17 Thurlow-street, Redfern.
1927		Price, William Lindsay, B.E., B.Sc., c/o Research Section, P.M.G. Dept., 360 P.O. Place, Melbourne
1918		Priestley, Henry, M.D., Ch. M., B.Sc., Associate-Professor of Physiology in the University of Sydney.
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 185 Macquarie-street.
1929		Pyke, Henry George, Chemical Testing Assistant, N.S.W. Government Tramways; p.r. Bellamy-street, Pennant Hills.
1927		Radcliffe-Brown, Alfred Reginald, M.A., *Cantab.*, M.A., *Adel.*, F.R.A.I., *Cantab.*, Professor of Anthropology in the University of Sydney.
1922	P 2	Raggatt, Harold George, B.Sc., "Meru," Epping-av., Epping.
1919	P 3	Ranclaud, Archibald Boscawen Boyd, B.Sc., B.E., Lecturer in Physics, Teachers' College, The University, Sydney.
1909		Reid, David, 'Holmsdale,' Pymble.
1928		Reidy, Eugene Nicholas, A.S.T.C., Analyst, Department of Mines, Sydney.
1924		Robertson, James R. M., M.D., C.M., F.R.G.S., F.G.S., 'Vanduara,' Ellamang Avenue, Kirribilli.
1928		Ross, Allan Clunies, B.Sc., 15 Castlereagh-street, Sydney. (Member from 1915 to 1924.)
1884	P 1	Ross, Chisholm, M.D. *Syd.*, M.B., Ch.M., *Edin.*, 225 Macquarie-st.
1895		Ross, Herbert E., Savings Bank Building, 14 Castlereagh-street, Sydney.
1927		Ross, Ian Clunies, D.V.Sc., "Lorne," The Grove, Woollahra.
1925		Roughley, Theodore Cleveland, Technological Museum, Sydney.
1929		Royle, Norman Dawson, M.D., Ch.M. 185 Macquarie-street, Sydney.
1907		Ryder, Charles Dudley, *D. Eng.* (Vienna), Assoc.I.R.S.M., (L.), Ass.A.C.I., F.C.S., (L.), Public Analyst (by appoint.), "The Astor," Macquarie-street, Sydney.

Elected		
1922		Sandy, Harold Arthur Montague, 326 George-street.
1920		Sawyer, Basil, B.E., 'Birri Birra,' The Crescent, Vaucluse.
1920		Scammell, Rupert Boswood, B.Sc., *Syd.*, "Storrington," 10 Buena Vista Avenue, Clifton Gardens.
1919		Sear, Walter George Lane, c/o J. Kitchen & Sons, Ingles-st., Port Melbourne.
1923	P 1	Seddon, Herbert Robert, D.V.Sc., Director, Veterinary Research Station, Glenfield.
1918		Sevier, Harry Brown, c/o Lewis Berger and Sons (Aust.) Ltd., Cathcart House, Castlereagh-street.
1924		Shelton, James Peel, M.Sc., B.Sc. Agr., Holland-av., Bellevue Hill.
1927		Shearsby, Alfred James, 152 Bland-street, Haberfield.
1917		Sibley, Samuel Edward, Mount-street, Coogee.
1900		‡Simpson, R. C., Lecturer in Electrical Engineering, Technical College, Sydney.
1922	P 1	Smith, Thomas Hodge, Australian Museum, Sydney.
1919		Southee, Ethelbert Ambrook, O.B.E., M.A., B.Sc., B Sc.Agr., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1921		Spencer-Watts, Arthur, 'Araboonoo,' Glebe-street, Randwick.
1917		Spruson, Wilfred Joseph, S.M. Herald Building, Pitt and Hunter-streets, Sydney.
1916		Stephen, Alfred Ernest, F.C.S., Box 1197 H.H.G.P.O., Sydney.
1921		Stephen, Henry Montague, B.A., LL.B., c/o Messrs. Maxwell and Boyd, 17 O'Connell-street.
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., Captain Piper's Road and New South Head Road, Vaucluse.
1920	P 1	Stephens, John Gower, M.B., Royal Prince Alfred Hospital, Camperdown.
1913		Stewart, Alex. Hay, B.E., 'Yunah,' 22 Murray-street, Croydon
1900	P 1	Stewart, J Douglas, B.V.Sc., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; p.r. 'Berelle,' Homebush Road, Strathfield. (President 1927.)
1909		Stokes, Edward Sutherland, M.B. *Syd.*, F.R.C.P. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1916	P 1	Stone, W. G., Assistant Analyst, Department of Mines, Sydney.
1927		Stump, Claude Witherington, M.D., D.Sc., Assoc.-Professor of Anatomy in the University of Sydney, p.r. 40 Shirley-rd. Wollstonecraft.
1919		Stroud, Sydney Hartnett, F.I.C., Ph.C., c/o Elliott Bros., Ltd., Terry-street, Rozelle.
1920		Sulman, Sir John, Kt., Warrung-st., McMahon's Point, North Sydney.
1918		Sundstrom, Carl Gustaf, c/o Federal Match Co., Park Road, Alexandria.
1901	P 12	‡Sussmilch, C. A., F.G.S., F.S.T.C., A.M.I.E. (Aust.), Principal of the East Sydney Technical College, and Assistant Superintendent of Technical Education. (President 1922. *Hon. Secretary.*
1919		‡Sutherland, George Fife, A.R.C.Sc., *Lond.*, Assistant-Professor in Mechanical Engineering, in the University of Sydney.
1920		Sutton, Harvey, O.B.E., M D., D.P.H. *Melb*, B.Sc. *Oxon.*, 'Lynton,' Kent Road, Rose Bay.

Elected		
1926		Tannahill, Robert William, B.Sc. *Syd.*, M.Sc., "Eastwell," 40 Cammaray Avenue, North Sydney.
1915	P 3	Taylor, Harold B., D.Sc., Kenneth-street, Longueville.
1905		‡Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1923		Thomas, David, B.E., M.I.M.M., F.G.S., 15 Clifton Avenue, Burwood.
1919		Thomas, John, L.S., 'Remeura,' Pine and Harrow Roads, Auburn.
1924		Thompson, Herbert William, 'Marathon,' Francis-st., Randwick
1913		Thompson, Joseph, M.A., LL.B., Vickery's Chambers, 82 Pitt-st.
1919		Thorne, Harold Henry, B.A. *Cantab.*, B.Sc. *Syd.*, Lecturer in Mathematics in the University of Sydney; p.r. Rutledge-st., Eastwood.
1916		Tillyard, Robin John, M.A., D.Sc., F.R.S., F.L.S., F.E.S., Chief Commonwealth Entomologist, Canberra, F.C.T.
1923		Timcke, Edward Waldemar, Meteorologist, Central Weather Bureau, Melbourne.
1923		Tindale, Harold, Works Engineer, c/o Australian Gas-Light Co., Mortlake.
1923		Toppin, Richmond Douglas, A.I.C., Parke Davis & Co., Rosebery.
1879		Trebeck, P. C., c/o Box 367 F., G.P.O., Sydney.
1925		Tye, Cyrus Willmott Oberon, Director of Development, Premier's Dept., Sydney; p.r. 19 Muston-st., Mosman.
1890		Vicars, James, M.E., Memb. Intern. Assoc. Testing Materials; Memb. B. S. Guild; Challis House, Martin Place.
1921		Vicars, Robert, Marrickville Woollen Mills, Marrickville.
1892		Vickery, George B., 9th Floor, Barrack House, Barrack-street. Sydney.
1903	P 5	Vonwiller, Oscar U., B.Sc., F.Inst.P., Professor of Physics in the University of Sydney.
1924		Wade, Rev. Robert Thompson, M.A., "Headfort," Pennant Hills, Parramatta North.
1919		Waley, Robert George Kinloch, 63 Pitt-street.
1910		Walker, Charles, 'Lynwood,' Terry Road, Ryde.
1910		Walker, Harold Hutchison, Vickery's Chambers, 82 Pitt-st.
1879		Walker, H. O., 'Moora,' Crown-street, Granville.
1919	P 1	Walkom, Arthur Bache, D.Sc., Macleay House, 16 College-st.
1903		Walsh, Fred., J.P., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, London; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; Regd. Patent Attorn. Comm. of Aust.; Memb. Patent Attorney Exam. Board Aust.; 4th Floor, Barrack House, Barrack-street, Sydney; p.r. 'Walsholme,' Centennial Park, Sydney.
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.

Elected		
1913	P 4	Wardlaw, Hy. Sloane Halcro, D.Sc. *Syd.*, Lecturer and Demonstrator in Physiology in the University of Sydney.
1922		Wark, Blair Anderson, V.C., D.S.O., M.I.Q.C., c/o Thompson and Wark, T. & G. Building, Elizabeth-street; p r. 'Braeside,' Zeta-street, Lane Cove, Sydney.
1921		‡Waterhouse, G. Athol, D.Sc., B.E., F.E.S., Curator of the Division of Economic Entomology, Canberra.
1924		Waterhouse, Leslie Vickery, B.E. *Syd*, 6th Floor, Wingello House, Angel Place, Sydney.
1919		Waterhouse, Lionel Lawry, B.E. *Syd.*, Lecturer and Demonstrator in Geology in the University of Sydney.
1919	P 3	Waterhouse, Walter L., M.C., D.Sc.Agr., D.I.C., 'Hazelmere,' Chelmsford Avenue, Roseville.
1919		Watkin-Brown, Willie Thomas, F.R.M.S., Lucasville Road, Glenbrook.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, University Club, Castlereagh-street; p.r. 169 Avoca-street, Randwick.
1910		Watson, James Frederick, M.B., Ch.M., 'Midhurst,' Woollahra.
1911	P 1	Watt, Robert Dickie, M.A., B.Sc., Professor of Agriculture in the University of Sydney. (President, 1925). *Vice-President.*
1920	P 24	Welch, Marcus Baldwin, B.Sc., A.I.C., Economic Botanist, Technological Museum.
1920	P 1	Wellish, Edward Montague, M.A., Associate-Professor in Mathematics in the University of Sydney.
1921		Wenholz, Harold, B.Sc.Agr., Director of Plant Breeding, Department of Agriculture, Sydney.
1881		‡Wesley, W. H., London.
1922		Whibley, Harry Clement, 39 Moore-street, Leichhardt.
1909	P 3	‡White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teacher's College.
1892	P 2	White, Harold Pogson, F.C.S., Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1923		Whitehouse, Frank, B.V.Sc., (Syd.), Hawkesbury Agricultural Agricultural College, Richmond, N.S.W.
1928		Wiesener, Frederick Abbey, M.B., Ch.M., D.O.M.S., 143 Macquarie-street, Sydney.
1921		Willan, Thomas Lindsay, B.Sc., c/o Alluvial Tin Malaya Ltd., Ho Hong Bank Bld., Market and Beach Streets, Penang, Straits Settlements.
1920		Williams, Harry, A.I.C., c/o Whiddon Bros.' Rosebery Lanolines Pty. Ltd., Arlington Mills, Botany.
1924		Williams, William John, 18 Bridge-street, Sydney.
1923		Wilson, Stanley Eric, 'Chatham,' James-street, Manly.
1891		Wood, Percy Moore, L.R.C.P. *Lond*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 11	Woolnough, Walter George, D.Sc., F.G.S., 'Callabonna,' Park Avenue, Gordon. (President, 1926.)
1916		Wright, George, c/o Farmer & Company, Pitt-street.
1917		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry in the University of Sydney.
1921		Yates, Guy Carrington, 184 Sussex-street.

Elected		HONORARY MEMBERS. *Limited to Twenty.* M.—Recipients of the Clarke Medal.
1918		Chilton, Charles, M.A., D.Sc., M.B., C.M., etc., Professor of Biology, Canterbury College, Christchurch, N.Z.
1914		Hill, James P., D.Sc., F.R.S., Professor of Zoology, University College, London.
1908		Kennedy, Sir Alex. B. W., Kt., LL.D., D. Eng., F.R.S., Emeritus Professor of Engineering in University College, London, 17 Victoria-street, Westminster, London S.W.
1915		Maitland, Andrew Gibb, F.G.S., Government Geologist of Western Australia, 'Bon Accord,' 2 Charles-street, South Perth, W.A.
1912		Martin, C. J., C.M.G., D.Sc, F.R.S., Director of the Lister Institute of Preventive Medicine, Chelsea Gardens, Chelsea Bridge Road, London, S.W. 1.
1928		Smith, Grafton Elliott, M.A., M.D., F.R S., F.R C.P., Professor of Anatomy in the University College, London.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., LL.D., Sc D., F.R.S., The Ferns, Witcombe, Gloucester, England.
1915		Thomson, Sir J. J., O.M., D.Sc., F.R.S., Nobel Laureate, Master of Trinity College, Cambridge, England.
1921		Threlfall, Sir Richard, C.B.E., M.A., F.R.S., lately Professor of Physics in the University of Sydney, 'Oakhurst, Church Road, Edgbaston, Birmingham, England.
1922		Wilson, James T., M.B., Ch.M. *Edin.*, F.R.S., Professor of Anatomy in the University of Cambridge, England. 31 Grange Road, Cambridge, England.

OBITUARY 1929-30.

Ordinary Members.

Elected.

1915 Armit, Henry William
1894 Balsille, George
1913 Bishop, Joseph Eldred.
1876 Codrington, John Frederic
1918 Elliott, Edward
1896 Fairfax, Geoffrey E.
1884 Henson, Joshua Binnington

Elected.

1880 McKinney, Hugh Giffin
1917 Ormsby, Irwin
1880 Palmer, Joseph
1909 Pigot, Edward Francis
1891 Poole, William
1918 White, Edmond Aunger

Honorary Member and Clarke Medallist:

1894 Spencer, Walter Baldwin.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. WILLIAM BRANWHITE CLARKE, M.A., F.R.S., F.G.S., etc.
Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

Awarded

1878 *Professor Sir Richard Owen. K.C.B., F.R.S.
1879 *George Bentham, C.M.G., F.R.S.
1880 *Professor Thos. Huxley, F.R.S.
1881 *Professor F. M'Coy, F.R.S., F.G.S.
1882 *Professor James Dwight Dana, LL.D.
1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S.
1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.
1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1886 *Professor L. G. De Koninck, M.D.
1887 *Sir James Hector, K.C.M.G., M.D , F.R.S.
1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.
1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.
1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.
1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.
1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., Sc. D., F.R.S., F.L.S., late Director, Royal Gardens, Kew.
1893 *Professor Ralph Tate, F.L.S., F.G.S.
1895 *Robert Logan Jack, LL.D., F.G.S., F.R.G.S.
1895 *Robert Etheridge, Jnr.
1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.
1900 *Sir John Murray, K.C.B., LL.D., Sc. D., F.R.S.
1901 *Edward John Eyre.
1902 *F. Manson Bailey, C.M.G.. F.L S.
1903 *Alfred William Howitt, D.Sc., F.G.S.
1907 Walter Howchin, F.G.S., University of Adelaide.
1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.
1912 *W. H. Twelvetrees, F.G.S.
1914 A. Smith Woodward, LL.D., F.R.S., Keeper of Geology, British Museum (Natural History) London.
1915 *Professor W. A. Haswell, M.A., D.Sc., F.R.S.
1917 Professor Sir Edgeworth David, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., The University, Sydney.
1918 Leonard Rodway, C.M.G., Honorary Government Botanist, Hobart, Tasmania.
1920 *Joseph Edmund Carne, F.G.S.
1921 *Joseph James Fletcher, M.A., B.Sc.,
1922 Richard Thomas Baker, The Crescent, Cheltenham.
1923 *Sir W. Baldwin Spencer, K.C.M.G., M.A., D.Sc.. F.R.S., National Museum, Melbourne.
1924 *Joseph Henry Maiden, I.S.O., F.R.S., F.L.S., J.P.
1925 *Charles Hedley, F.L.S.
1927 Andrew Gibb Maitland, F.G.S., "Bon Accord," Melville Place, South Perth.
1928 Ernest C. Andrews, B.A., F.G.S., Government Geologist, Depart- of Mines, Sydney.
1929 Ernest Willington Skeats, D.Sc., A.R.C.S., F.G.S., University of Melbourne, Carlton, Victoria.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

1882 John Fraser, B.A., West Maitland, for paper entitled 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper entitled 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper entitled 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper entitled 'The Tin deposits of New South Wales.'

1887 Jonathan Seaver, F.G.S., Sydney, for paper entitled 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.'

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper entitled 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for paper entitled 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.'

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper entitled 'The Australian Aborigines.'

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper entitled 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper entitled 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper entitled the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper entitled 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, D.Sc., M.B., F.R.S., Sydney, for paper entitled 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper entitled 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

AWARDS OF THE WALTER BURFITT PRIZE.

MONEY AND MEDAL.

Money Prize of £50.

Established as the result of a generous gift to the Society by Dr. W. F. Burfitt, B.A., M.B., Ch.M., B.Sc., of Sydney. Awarded at intervals of three years to the worker in pure and applied science, resident in Australia or New Zealand, whose papers and other contributions published during the past three years are deemed of the highest scientific merit, account being taken only of investigations described for the first time, and carried out by the author mainly in these Dominions.

Awarded

1929 Norman Dawson Royle, M.D., Ch.M.

PRESIDENTIAL ADDRESS

By W. Poole, M.E., M.Inst.C.E., M.I.M.M., etc.

Delivered to the Royal Society of New South Wales, May 1, 1929.

During the past year the Society has maintained its activities and membership.

The Imperial Geo-physical Experimental Survey is conducting investigations in Australia in conjunction with the State Authorities and the Council of Industrial and Scientific Research. The object of these investigations is to ascertain if geo-physical methods of prospecting are applicable in Australia to make a mineral survey of the country.

The fourth Pan-Pacific Conference is to hold its next meeting in Java and the Australian delegation to the Conference has just left for Java. Mr. E. C. Andrews was appointed leader of the Australian delegates.

At the request of the Great Barrier Reef Committee, which was inaugurated in 1922 by the Royal Geographical Society of Australasia, Queensland Branch, a well-equipped expedition was organised by the British Association for the Advancement of Science, to make a biological survey of the Great Barrier Reef. The expedition, which is under the leadership of Dr. C. N. Yonge, Balfour Student of the University of Cambridge, has now been at work for about ten months, and will conclude its operations in July next. One of the primary objects of the expedition is to enquire into the conditions which govern the growth of coral and

associated animals and plants, the nature and variation in the quantity of the plankton, minute organisms upon which larger animals feed, and the salinity, temperature and other conditions of the sea water. The bottom fauna and flora is being examined and a representative collection of the animals and plants which live on and about the Reef is being made. Economic possibilities are also being investigated and it is hoped that important results of scientific interest and also of practical utility will be achieved. The members of the expedition are well qualified by training and experience in the laboratories of the Old World, and they have had the co-operation of a number of Australian workers, whose local knowledge has been, we hope, of considerable service, and who, on the other hand, have gained valuable experience in up-to-date methods of marine investigation.

Recently Australia was visited by the Danish exploring vessel "Dana," which is making a two years' round-the-globe trip for the purposes of oceanographical research. The scientific staff is headed by Dr. Johannes Schmidt, Director of the Carlesberg Laboratory, Copenhagen, a zoologist and marine explorer of international reputation, who is perhaps best known as the world's foremost student and authority on the natural history of the eel. The "Dana" will investigate the depths, temperatures, salinities, and the general physical and chemical characters of ocean waters, and collect samples of the animals and plants which live in the sea. We may confidently expect that much new and useful knowledge will result from the researches of the Danish scientists, who have already done so much to advance our knowledge of oceanography.

The British Barrier Reef and the Danish Oceanographical Expeditions are strong reminders to the people of Aus-

tralia of the vast amount of research work that is overdue, in investigating the marine biological resources of the Australian tropical and temperate seas. The detail charting of the great maze of reefs and channels of the Great Barrier Reef also should be pushed to completion.

During the year I attended a meeting at the Sydney Observatory as one of the official visitors and was brought into close personal contact with the work being carried out at the Observatory.

One of the most important factors in the solution of some of the immense problems confronting astronomers is a knowledge of any change in the positions of celestial bodies. It is not too much to say that were astronomers to-day in possession of exact knowledge as to the positions of stars and nebulae made a thousand years ago, our knowledge of the extent and mechanics of our and other universes would be vastly greater. With a view to a very systematic measurement of the positions of the stars, and having also in view the fact of the then beginning-to-be-used photography in astronomical work, a conference of astronomers, representing all the civilised nations of the world, met at Paris in 1887. After much discussion, a plan was finally agreed upon. This plan involved the making of a Great Star Catalogue, from measures of photographic plates. The sky was divided into zones, and a number of zones were allotted to the different National Observatories. The late Mr. H. C. Russell, who represented Victoria and New South Wales, accepted, on behalf of the Governments of these two States, the responsibility of making the photographs and the consequent measures of the plates in the zones that were allotted to the Observatory at Sydney and publishing the results. On Mr. Russell's return to New South Wales, the Government acquiesced

in all that he had done, and bound this country to this great National Convention in the carrying out of the work allotted to it. Further than this, Mr. Russell was authorised to set to work at once on the work of the zones allotted to Sydney. Though the work has been carried on ever since by Mr. H. C. Russell, Professor W. E. Cooke, and Mr. J. Nangle, the work at Sydney has not yet been completed. There have been many delays, which have not been very creditable to New South Wales.

Some little time ago, the Government of the day decided to disestablish the Observatory. Fortunately, it was led to reconsider its decision, with the result that the Observatory is being carried on, but with a very much smaller staff. In addition to the routine work of conducting the time service and many other matters connected with the requirements of civil astronomy in the State, the Star Catalogue is being proceeded with. At the present rate I am informed it will be ten years before it is completed. Besides the work of taking the photographs, measuring the plates, and the reductions of the measures, there is also the obligation to publish the results in catalogue form. In all, there will be 36 volumes of measures. Up to the present, six volumes have been published.

The Government is strongly urged to continue with this work at the present rate, if not a little faster, and, further, to publish the observations. In doing this, it will not only be carrying out the contract which it made in the first instance, but will be doing a lot more, in that it will be making a contribution on behalf of this State to the accumulation of that general knowledge of facts which are so important towards the continued enlightenment and advancement of the human race.

UTILISATION OF THE WATER RESOURCES OF AUSTRALIA.

The future progress of Australia will depend on closer rural settlement and the development of industrial, business and residential urban areas which will necessitate the proper utilisation of the water resources of the country to yield adequate supplies for domestic, urban and industrial centres, stock, intense cultivation and grazing, hydro-electric power, navigation, hydraulic sluicing, etc.

Rainfall.

The source of all water supplies, including artesian water, is the rainfall. The rainfall in Australia varies in a most remarkable manner as to the average amount, percentage variation for wettest and driest years and periods of monthly distribution, heavy storms, intensity of downfall, evaporation, etc. The subject of the rainfall and the utilisation of its run-off in Australia is a wide subject; my remarks, excepting artesian water, will be confined to the State of New South Wales, but are in a general way applicable to the rest of Australia.

The distribution of rainfall in New South Wales is included in the accompanying table, which is based on official publications.

The table shows that there is a great range of average annual rainfalls ranging from very high on the coast, to very low in the far west of the State. Maximum or minimum "one year" rainfalls in any district have a very great proportional range above or below the average rainfall. This range is greater than in most temperate climates. There are long periods ranging from seven to eleven years in various districts during which the rainfall may be continuously above the average, and from five to eleven years during which it may be continuously below the

RAINFALL RESULTS (based on official returns).

	Average Ann. inches	Max. Year per cent.	Min. Year per cent.	Above average		Below average		Max. 1 month per cent.	Max. 1 day per cent.
				Years	per cent.	Years	per cent.		
Coastal Districts, N.S.W. ..	35–50	150–180	50–60	7–11	120–135	5–10	80–85	40–90	15–30
Tablelands, N.S.W.	28–32	150–160	60–70	6	120–130	5–6	82–86	30–50	10–20
Western Slopes, N.S.W. ..	24–27	160–170	55–60	6	122–132	6–9	83–87	35–40	12–22
Western Plains, N.S.W. ..	16–22	160–180	45–55	6	130–140	8–11	78–86	35–55	10–25
Western District, N.S.W. ..	10–15	175–185	35–45	6	116–136	6–10	67–75	50–130	25–60
Rockhampton, Q.	56	215	40	6	132	5	77	155	30
The Springs, Tasmania ..	61	166	59	—	—	5.5	87	34	—
Great Britain	All stations	145	66	—	—	5	82	—	—

Note.—The various columns under "per cent." are percentage values of the average rainfall for each district or place.

average. These periods of deficient rainfall usually contain several successive years of severe drought. Close examination of rainfall records during droughts show that not only are the total rainfalls low, but they are often made up of small falls of rain of little or no value to vegetation, and they are of such character that there is no run-off. There are often long periods between heavy downpours which give useful run-offs from a catchment. The great rate of evaporation, usually much above the average in drought periods, materially increases the difficulties of securing an amount of stored water, which will ensure a sufficiency of water supply during years of deficient rainfall. On the other hand, there may occur single rainstorms which will fill the storage basins.

The rainfall in the Coastal, Tableland and Western Slopes Districts of New South Wales is, on the average, ample for appropriate agriculture, and in places where the soil is rich, also for intense grazing of stock. Drought years cause serious loss of crops and feed for stock, and emphasise the necessity of growing and conserving fodder for feeding stock—especially on intense grazing areas during periods of fodder deficiency. Irrigation can be applied with great advantage to intense culture, and for growing fodder for intense grazing, even in districts where the normal rainfall is good.

It is necessary in most localities to augment the ordinary water supplies in creeks, etc., by conservation in tanks, dams, etc., or by obtaining water from wells.

In the Central Plains and in the Western District, the rainfall is light, in the southern Central areas is usually both sufficient in amount, and seasonable in time, for profitable wheat growing. It is, however, necessary—at large expense, except on the rivers—to conserve water on a

liberal scale for stock purposes. Irrigation is necessary for intense culture, and under favourable conditions of soil gives excellent cultivation results, as at Yanco and other irrigation settlements.

There is, on the average, a sufficiency of rainfall in the Western District to grow highly nutritious feed for light grazing. The great losses of stock that have at times occurred during drought have been due, in most cases, to a failure of conserved water, rather than to a failure of feed. The northern portions of the Central Plains and Western Districts are in the Great Australian Artesian Basin area, in which, since there has been an adequate perennial supply of artesian water, the losses of stock have been mostly due to failure of feed.

EVAPORATION.

Spontaneous evaporation of water from open water surfaces, soil and vegetation, is very large in this State, and is a serious factor affecting the run-off from catchment areas, storage of water, and the preservation of moisture in the soil for vegetation. The variations of evaporation in New South Wales are shown in the accompanying table, which is based on official returns:

Districts.	Average (approx.) in inches. Year.	December.	June.	Maximum day in inches. December.	June.
Coastal	35-45	5-6	1.25-1.75	.4-.6	.20-3.5
Tablelands..	35-50	5-7	1.0-1.75	.35-.6	.15-.20
Western Slopes ..	45-60	6-9	1.25-2.0	.4-.7	.20-.25
Western Plains ..	55-65	8-10	1.75-2.5	.6-.8	.20-.30
West	65-80	9-12	2.0-3.0	.7-1.0	.22-.35

The average annual evaporation exceeds the average annual rainfall for the whole of the State, except in a narrow strip along the coast. It is only in such latter areas that there is any marked development of dense vegetation or jungle growth.

The experiments carried out over many years by the late Mr. H. C. Russell, a late Government Astronomer, showed that the evaporation from bare and grassed surfaces of saturated soil were respectively 80 and 102 per cent. of that from open water, which shows that water is rapidly evaporated from all saturated surfaces.* The temperature, velocity and relative humidity of the air have very marked influence on the rate of evaporation.

During periods of very hot, dry winds, the evaporation, especially from wide shallow bodies of water, has been known to have a rate of evaporation exceeding an inch per day. There are great losses from evaporation and percolation from water in natural and artificial channels. Careful gaugings of the rivers of the Murray-Darling System show that there is a marked and decreasing diminution of average flow at successive gauging stations after passing the last of the foot hills. Take as an example the Lachlan River, where the last of the confluent streams enter the river near Condobolin. The annual average flows taken over many years at the gauging stations are published by the Water Conservation and Irrigation Commission,† and from these data I have prepared the following tabulated statement.

	Annual flow average of all years.		Low years 1899 to 1910 except 1900 and 1906.	
	Acre feet	%	Acre feet	%
Cowra	362,927	92.2	178,700	82.7
Forbes	384,066	100.0	216,000	100.0
Condobolin	301,268	78.4	143,900	66.6
Euabalong	280,998	73.2	109,600	50.8

The average of all years contains the loss of water due to effluent streams as well as by direct and indirect

* See Results of Rain, River and Evaporation Observations made in New South Wales, by H. C. Russell, annual vols. 1885-1902.

† Report of Commissioner for Water Conservation and Irrigation, 1914.

evaporation. The average of ten low years contains very little loss of effluent streams; the difference in flow between Forbes and Eubalong may be taken as roughly approximating to the losses by evaporation.

The average annual flow at Wilcannia on the Darling River is approximately 3,320,000 acre feet and at Menindie is 2,840,000 acre feet** or about 85% of the flow at the former station. The loss in flow between the two stations is closely approximate to the calculation of evaporation loss from an area equal to that of the river surface between the two places.

The decreasing flow in our western rivers is accompanied by a decreasing area of cross section. The diminishing cross sections of the Macquarie River from Dubbo to Mount Harris are given in a paper which I wrote in 1898.*

It is well known that water from artesian bores flows along drains to a markedly greater distance in winter than in summer, the difference in flow being due to the difference in evaporation.

The evaporation from stored water is so great, and the dry periods or droughts so long, that water should be stored in deep reservoirs, dams, excavated tanks, etc. The loss of water by evaporation from the wide, shallow Stephens Creek Reservoir near Broken Hill during hot, windy months was ten times that used in supplying the needs of Broken Hill. The more recent dam in the Umberumbica Creek is very much deeper, with a consequent lessening of the proportion of water lost due to evaporation.

Supply from Subsurface Gravel and Sand Deposits.

A very important and permanent source of supply is subsurface water contained in the deposits of gravel and

** ibid.

* The Warren Weir, by W. Poole. Proceedings of Sydney University Engineering Society, 1898.

sand which underlie plains and extend laterally from river beds. The course of rivers may be divided into two main sections, viz., the upper, where the river bed is being cut down into the underlying strata; and the lower, in which the bed is being raised by material brought down from the upper portions. There are instances in which, owing to tectonic movements of the earth's crust—e.g., on the Lower Murray River in South Australia—a section of a degrading river course is interposed between aggrading lengths. The neutral point between the degrading and aggrading courses is usually well within the foot hills and gradually works up the stream. In some streams, especially on the coast, aggrading lengths and areas are relatively short and small. On the other hand, on the western rivers of this State, the aggrading courses may be very long. The vast alluvial plains of the Murray-Darling system of rivers are comprised within the aggrading area.

Many streams and rivers in their upper or degrading courses and all rivers in their lower aggrading courses, have extensive alluvial flood plains along the river banks. The plains are underlain by sands and gravels in direct and close communication with gravel in the beds of the river. These lateral underlying gravel and sand beds contain water which stands at about the low water level of the river, but fluctuates to a lesser degree with the water level of the stream.

These bodies of underground water are utilised only to a very moderate degree. The water from these gravel beds may be regarded as filtered river water, and more extensive use of it should be made for domestic and stock purposes, and for irrigation of limited areas.

Rivers in their aggrading areas have built up extensive alluvial plains, and in doing so have meandered over the whole or most of these extensive areas. Though the surface

may be of sandy loam to stiff clay, the beds of such rivers are composed of boulders, gravel or sand, which gradually get smaller in lumps or grains as they are worked down stream. The river during its wanderings gradually raises its bed, leaving layers of gravel and sand which are mostly in continuous connection with the existing river beds, though this connection may be, and often probably is, very circuitous, the rest of the alluvial strata being sand clay and clays which have been laid down by flood water above the ordinary low water river bed.

These clay beds form impervious containers for the water bearing sand and gravel beds. When these beds are pierced by wells or bores the water frequently rises to a considerable height in the well or bore. These water bearing beds have been proved to exist over wide areas. They form pumping supplies which are receiving active and marked attention in some districts—e.g., the plains between the Castlereagh and Macquarie Rivers, where they are becoming the principal source of water supply for stock. The water from such sources, especially from the shallower ones, is of the surface well type. As these wells do not overflow, they cannot be wastefully exhausted, and are therefore permanent supplies which may be expected to become somewhat better in quality as the underground stores of water are made to circulate by drawing upon them. There are fewer layers of water bearing sands in districts where the alluvial plains are being mainly built up by effluent streams from the river. Water supplies are here fewer and more difficult to find; nevertheless they are of great importance—e.g., in that large area roughly bounded by the Murrumbidgee, Lachlan and Darling Rivers and the Willandra Creek. Many comparatively shallow non-artesian supplies have been found over very large areas, when putting down bores to the great deep-

seated artesian supply, but as the former did not come to the surface they were neglected. As the cost of deep artesian bores is great, and coupled with the gradually diminishing surface flows or cessation of flow, these comparatively shallow supplies must eventually receive more active attention and exploitation. There is little doubt that there are ample supplies of water for all stock purposes below the wide alluvial plains which constitute a large proportion of the area of this State. All that is necessary is to locate and obtain them.

Artesian Supplies.

The Great Artesian Basin of Australia is the largest known artesian basin in the world, and has an area of over 500,000 sq. miles, that is, about one-sixth of the area of Australia. It extends over an area in Queensland of 327,000 sq. miles, New South Wales 70,000 sq. miles, South Australia 102,000 sq. miles, and Central Australia about 18,000 sq. miles.

The Great Artesian Basin has been of enormous value to the above States by enabling an adequate and absolutely certain supply of water over an enormous area, where it would be very difficult to conserve water in ordinary seasons, and which would otherwise, in great part, fail in periods of drought. The inestimable value of artesian water in the dry and poorly watered pastoral districts of the interior was early recognised and enormous sums of money have been spent in obtaining supplies from shallow to great depths. Much of the artesian water was, and is, used in a manner that is nothing short of useless wanton waste, as if the supply were inexhaustible. Many owners have strongly resented any efforts on the part of the Government of their State to regulate the uncontrolled flow of water from their bores. Governments, being political bodies influenced by public opinion, have been

backward in adopting the recommendations of their responsible officers, who are keenly alive to the national danger of overdrawing upon the artesian water supplies. It is quite certain that the supply of water from this great basin is not unlimited in quantity. Investigations carried out by the controlling water authority in each State show that both the water pressure and flow are decreasing over the whole basin. There are grave misgivings that the artesian flowing wells in large districts will cease to overflow and become pumping supplies with an ever-increasing depth to the surface of the water. Many flowing wells have already ceased to flow. The supply in the artesian beds is replenished by water which enters along lengths of porous outcrops in Queensland, New South Wales and Central Australia. The friction of water in flowing through porous sand and gravel beds is so great as to reduce the velocity of flow to a very small amount—so small, in fact, as to cause the replenishing supply stream to be strictly limited in quantity, even if the supply at the intake be exceedingly large and always available. There is little doubt that the total discharge of all bores greatly exceeds the replenishing supply.

The progressive and increasing depletion of the artesian water supply is such a serious national matter that I shall freely quote and summarise figures and statements given in the reports of the Interstate Conferences on Artesian Water, which have been held during the past sixteen years.

The report of the First Interstate Conference (1912) showed that in Queensland there were 785 flowing bores with a total flow of 517 million gallons per diem (mil-gal-day) and 329 wells from which were pumped about 10 mil-gal-day. In New South Wales there were 380 flowing wells giving a total flow of about 111 mil-gal-day, and 74 bores with pumping supplies.

The report of the Second Conference (1914) showed that in New South Wales there was a general falling off in flow, and gives a table which shows that the decrease in flow is greatest during the earliest period of flow, and that the percentage of decrease lessens with increasing years. Queensland reported a general decrease in flow in 977 flowing bores. Bores which had been gauged for 15 years showed an average decrease of 40 per cent. of the aggregate flow, or an average decrease of 2.9 per cent. per annum. Pressure tests also showed a marked decrease.

The report of the Third Conference (1921) showed that in Queensland there were 1236 flowing bores and that there was an average decrease in total supply of 2.07 to 2.27 per cent. in the south-western districts and 3 to 5 per cent. in the northern districts. The average reduction in water level in non-flowing bores was about 3 feet per annum. Bores that had ceased to flow numbered about 11 per cent. of the total originally flowing bores. Attention was drawn to the enormous waste of flowing water from privately owned uncontrolled bores. In New South Wales 331 out of 381 flowing bores had been regularly gauged from 1914 to 1921 and showed a total decrease in flow of 22.29 per cent. for the period, or 3.18 per cent. per annum. The average reduction in water level in non-flowing wells was 2.60 feet per annum. The conference, referring to the portion of the Great Artesian Basin in South Australia, stated that:—

> "the future of the pastoral industry in this region depends upon the careful husbanding of the water resources stored beneath the surface. No surface supplies can be relied upon in the north-east of South Australia by reason of the low rainfall" (5 to 7 inches per annum) "and great evaporation" (110 to 120 inches per annum), "and artesian supplies have an

importance in this region that they do not possess in districts favoured with better climatic conditions. We therefore strongly recommend . . . that effective means be taken to prevent waste."

The report of the Fourth Interstate Conference (1924) showed that in New South Wales about 9 per cent. of flowing bores had ceased to flow, and the decrease in water level in these bores was about 1.55 feet per annum. A number of bores were closed or partially closed at different times, with the result that the rate of decrease in discharge was in such cases to some extent arrested.

The report of the Fifth Conference (1928) has not yet been published. I have been verbally informed that, *inter alia,* the following figures were supplied to the members of the Conference, viz.—The total discharge of all bores in Queensland and New South Wales in 1912 was 627 mil-gal-day,* and was about 500 mil-gal-day in 1921, and had fallen to about 400 mil-gal-day in 1928.** There has thus been a decrease of 227 mil-gal-day in 16 years, equal to a total decrease of 36 per cent., or an average of 2.25 per cent. per annum.

In 1912 the total artesian flow in Queensland and New South Wales was about equal to the summer flow of six rivers of the type of the Lachlan, Macquarie, Castlereagh, Namoi, Gwydir and MacIntyre Rivers and the falling off in flow has been equal to the loss of two such rivers.

The great decrease in the flow of bores in artesian basins has also been closely investigated in America. For the North Dakota Artesian Basin—

* See Report of First Interstate Conference on Artesian Water.

** From E. C. Andrews, Government Geologist of New South Wales.

"it was estimated in 1923 that in the east-west row of townships under special investigation the rate of discharge from the artesian wells averages close to 3000 gals. a minute in the 38 years since the first well was drilled in 1886. The rate of discharge was estimated to be nearly 10,000 gals. a minute during the period of peak of some period between 1905 and 1910, about 5,000 gals. a minute in 1915, about 2,000 gals. a minute in 1920 . . . it was almost exactly 1,000 gals. a minute in 1923."***

This American investigation shows that the outflow has decreased to one-tenth of its maximum flow, and should of itself, quite apart from the investigations of the Interstate Conferences, show the great danger of failure or seriously diminished flowing supply in the Great Artesian Basin of Australia.

It is customary to distribute the water from flowing bores by means of drains cut in the soil. The loss of water from these drains by percolation and evaporation is exceedingly great. Most of the water from flowing bores is consumed in this manner; the percentage actually used for stock and domestic purposes is very small. A much greater area of distribution, combined with a great economy of water, can be obtained by the use of pipes as has been necessary, highly effective, and economical in the rural water supplies of South Australia. Individual owners may soon be forced to such means of distribution and economy in use, especially when the overflow of the bores becomes very small, or ceases and becomes a pumping supply. All bores should be treated to prevent underground water losses, and so that they can be shut down effectively and with safety, to give a diminished flow.

*** O. E. Mereiger re Compressibility and Elasticity of Artesian Aquifers—Economic Geology, Vol. XXIII., p. 269, 1928.

The State authorities may, in the comparatively near future, be forced to compel such a distribution and rationing of a rapidly diminishing available supply of artesian water.

The Great Artesian Basin is one of the greatest national assets possessed by the Commonwealth. The problems of its preservation and efficient utilisation are of the greatest national importance. Much has, and is, being done by the owner States, but more effective measures will be necessary in the near future to minimise waste and unprofitable use, if the artesian supply is to remain a great and effective national asset.

STORAGE SITES.

The streams and rivers which flow east to the coast or west to the Murray and Darling Rivers have their sources in a series of tablelands which have, in most cases, been deeply dissected on their flanks. Most of the tributaries as well as the main rivers have one or more sites admirably formed and situated for large storage dams. Many of these sites have already been utilised—many works are under construction or are under serious consideration.

For instance, confining my remarks to New South Wales, there are, on the coastal rivers, the Cataract, Avon, Cordeaux and Chichester high concrete dams and the Prospect earth dam in operation, the Nepean and Woniora high concrete dams are under construction, the George's River concrete dam is approved for early construction, and the giant dam on the Warragamba River is under serious consideration. On the western streams are the Burrinjuck, Cotter and Umberumbica concrete dams and Stephens Creek earth dams in operation. On the Murray River there is the Hume Dam, the largest but one storage reservoir in the world, in an advanced stage of construction, and on the Lachlan River the Wyangala Dam is in

the preliminary stages of construction. Besides these, there are a large number of high thin-arch concrete dams for country towns' water supply.

New South Wales is famous in the world for its great number of high concrete dams, built, in progress, or shortly to be commenced.

Impounding Schemes.

It is rarely that irrigation schemes become financially profitable before the whole scheme is in full operation, and many such schemes have had to be relieved of a large portion of their capital cost before they have become payable propositions.

Irrigation settlements such as Mildura, Renmark, Coomealla, etc., and many private irrigation properties pump direct from the Murray and other rivers, and are not financially burdened with the cost of providing expensive impounding and storage works. Even with the latter expense, they have become payable only with careful management.

In the Burrinjuck-Yanco Irrigation Scheme, it was expected and intended that the irrigation settlement should meet the interest on the great cost of impounding and river regulation scheme, as well as the distribution, etc., scheme at the irrigation settlement. The scheme on this basis has been a distinct failure. The cost of the impounding works should not have been charged to the irrigation settlement. The regulation of the river, however, has been a great benefit to riparian holders.

It is difficult to outline any fair financial scheme whereby such works as the Hume and Wyangala Dams can be made directly to pay working expenses and interest on capital cost. The interest on the cost of intake and distribution and working costs should be met by all irrigation settle-

ments, but the cost of large impounding schemes (except for town water supplies), whether intended to supply one or more irrigation settlements, navigation, general settlements, etc., should be classed as national works, and be a general charge on the community, as is the case for the cost of improvement of bar harbours, roads and (as also in fact) for branch developmental railways, the benefit to the State being settlement and general prosperity. Unless this is done it is highly improbable that the vast national asset of the water in our rivers, especially in our inland rivers, can be beneficially and fully developed.

Western Rivers and Effluent Streams.

The rivers in the western slope of the Great Dividing Range flow past the last of the foot-hills out on to immense alluvial plains, where the main stream has numerous effluent channels. Many of these effluent channels return to the main channel, but numerous streams do not, or only to a small extent, return to the main stream. Most of these effluent streams do not flow until the main stream is at least half-bank high. These effluent streams are a natural, though wasteful, means of usefully distributing water over very wide districts. Large storage schemes will have the effect, except in time of high flood, of regulating the flow in the river and lessening the frequency and amount of flow in the effluent streams. Large storage schemes should therefore be accompanied by appropriate works to regulate the supplies to effluent channels.

Town Water Supplies.

More effective and efficient use must be made of catchment areas for town water supplies. Water from unpopulated or but thinly populated and strictly regulated areas is advantageous, but such schemes may be unjustifiably expensive when the use of undoubtedly effective methods of treating and purifying water for domestic consumption

may enable a cheaper and more certain supply to be adopted. Valuable land may also be saved for useful and needed settlement.

The rapid increases in population in metropolitan and industrial areas may make it very difficult to get sufficient unpopulated catchment areas except at such great distances as to cause an unjustifiable cost of construction and operating.

Colonel F. F. Longley, who came from the Rockefeller Institute, to advise the Commonwealth and State Governments on the hygiene and sanitation of towns, remarked to me that too much reliance was placed, in Australia, on the purity of untreated water from unpopulated areas, that some of the untreated waters for our big cities contained too many bacteria, and that at times the typhoid rate was much too high, and probably connected with the domestic use of untreated and unpurified water.

Most towns and cities in Britain, the Continent of Europe and the United States are forced to obtain their water supplies from populated—often densely populated—catchment areas. Almost the whole of the water supplies for the vast population of London are obtained from sources which, in Australia, would be considered highly polluted. The water is treated by settlement and filtering to remove earthy turbidity and bacteria, and as supplied to the public is noted for its great purity and wholesomeness. The same remarks apply, with even greater force, to the water supplies of the towns and great cities which are built on many of the inland rivers of the United States of America. The treated effluent of the sewerage works of some cities must, perforce, run into streams which become the water supply for populations lower down stream, and for whom the only available water supply is the river. The water is treated for turbidity, bacteria, colour and odour

and the regulation of hardness. A very soft water, though very acceptable for washing and as boiler feed, is not so wholesome for drinking; it also allows a more rapid corrosion of iron and steel pipes, and causes a secondary deterioration, in the pipes, of the quality of the water in the pipes.

The results obtained from the working of the new supply and treatment scheme for the City of Rockhampton in Queensland, with the installation of which I was closely associated, show that highly successful and certain results can be obtained from a supply of a very varied character. The water is obtained from the Fitzroy River, which has a lightly-populated catchment with a few towns of small magnitude. During periods of low river the water has a low turbidity, high hardness, a distinct green colour, frequently a distinctly weedy taste and smell, the general bacteria count is high, while the count of dangerous bacteria, such as *B. coli,* may be unpleasantly high. During floods, the turbidity, during the first fresh after a long dry spell, may be as high as 7000, on Hazon's scale, and the hardness is low. No great difficulty has been experienced in supplying, with certainty under all varying conditions, a water of negligible turbidity, a regulated hardness, good colour, and freedom from bacteria, weedy taste and smell. Such water is supplied to the newly reticulated areas and to the town reservoir, but the water passing through the old reticulation mains receives secondary contamination from the deposits from the previous water supply. The total cost of treatment and filtration, including salaries, labour, material, repairs and interest on capital expenditure of the plant is less than two-pence per 1000 gallons.

The Nepean catchment area is reaching its maximum average supply capacity, and it will be necessary, in the very near

future, to augment the Sydney Water Supply from some other source. The catchment of the Wollondilly, Cox and Warragamba Rivers has been proposed, but strong objection has been taken, in some quarters, to the fact that it is a polluted source, overlooking the fact that these waters are already the source of supply for the towns of Penrith, Richmond and Windsor. The grosser forms of pollution can be prevented by law and rigid inspection. The supply should be treated and filtered, but it may also be advisable to similarly treat the water from the other sources.

PRELIMINARY NOTE ON NEW SUBGENERA OF *PRODUCTUS* AND *STROPHALOSIA* FROM THE BRANXTON DISTRICT.*

By F. W. Booker, B.Sc.,
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(With Plates I-III.)

(Read before the Royal Society of New South Wales, June 5, 1929.)

The Specimens herein described were collected in the Branxton district during 1928 by a field party working under the direction of Mr. M. Morrison, Geological Surveyor, of which the author was a member.

The specimens show so many new and remarkable characters that it was thought advisable to publish descriptions and figures immediately and to leave more detailed systematic work for a future paper.

I am greatly indebted to Mr. W. S. Dun, Palæontologist, Department of Mines, for his very valuable advice. I have also to thank Dr. C. Anderson, Director of the Australian Museum, and Mr. J. Kingsley for their valuable assistance.

Genus—Strophalosia, King, 1844.

Subgenus—Wyndhamia, Subgen. nov.

Pl. I., figs. 1-5; Pl. II., figs. 1-5; Pl. III., figs. 4-7.

Shell large, plano-convex and regularly spinose, with a median sinus on the pedicle valve. Hinge line nearly as long as the greatest width of the shell. A well marked area is developed in both valves. The ears are well developed, flattened and usually without ornamentation. The

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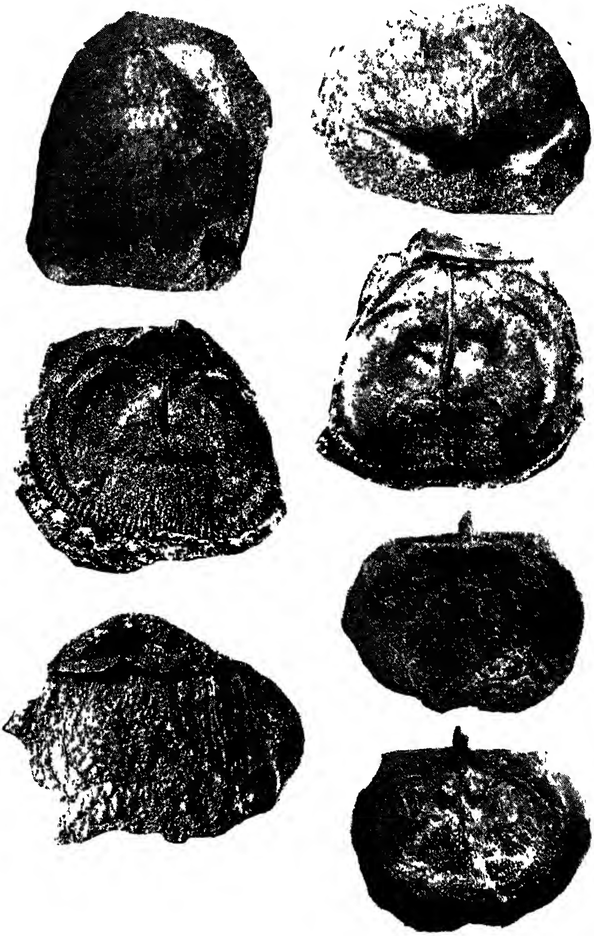


1 2 3 4 5 6 7

Figs 1 – 5—*Wyndhamia dalwoodensis,* Sp. nov.
Figs. 6, 7—*Strophalosia gerardi,* King.

brachial valve is flat and sometimes very thick, particularly at the anterior margin. The hinge teeth are strong and well developed, fitting into deep sockets in the brachial valve. A long septum is developed in the brachial valve and extends anteriorly nearly two-thirds of the length of the valve. The cardinal process is strong and inclined. It is bifid anteriorly and quadrified posteriorly. (See Pl. II., fig. 5; Pl. III., figs. 4 and 6.)

A specimen of *Strophalosia geradi,* King, from Jump-up Creek, where it crosses the boundary of Parishes of Belford and Ovingham, County of Northumberland, is figured for comparative purposes (Pl. I., fig. 6, 7), and shows the remarkable resemblance of its cardinal process to that of *Wyndhamia.* The adductor muscle scars of the brachial valve are flabellate and cannot be differentiated into anterior and posterior elements. They are triangular in shape, with one side parallel to the septum, the apex directed posteriorly and the base raised considerably above the general level of the valve forming the blunt prominence common to most species of *strophalosia.*

The brachial supports are directed postero-laterally from near the middle of the muscle scars and run sub-parallel to the shell margin to the antero-lateral margin, then curve sharply backwards, then inwards, but not meeting the median septum. (Pl. I., figs. 3 and 4; Pl. II., fig. 4.)

Type, *Wyndhamia dalwoodensis,* Sp. nov.

Locality, Por. 147, Parish of Branxton, County of Northumberland.

WYNDHAMIA DALWOODENSIS, Sp. nov.

Pl. I., figs. 1-5; Pl. III., figs. 5, 7.

Shell moderately large and plano-convex, with beak incurved.

The pedicle valve is covered with spines which seem to be more or less regularly arranged in concentric rows. The ears apparently do not bear spines, but are well defined and sometimes ornamented with a few ribs. The brachial valve is flat or slightly concave and generally thin. The hinge line is long, but not equal to the full width of the shell. There is an area in both valves (Pl. I., fig. 5), and the teeth are strongly developed, fitting into deep sockets in the brachial valve. (Pl. I., fig. 2.) The cardinal process strongly resembles that of *Strophalosia*, being slightly inclined, bifid anteriorly and quadrified posteriorly. The adductor muscle scars in the brachial valve are flabellate and cannot be differentiated into anterior and posterior elements. The brachial supports are directed postero-laterally from near the middle of the adductor muscle scars and run sub-parallel to the shell margins to the antero-lateral margin, then curve sharply backwards and then inwards, but do not meet the median septum.

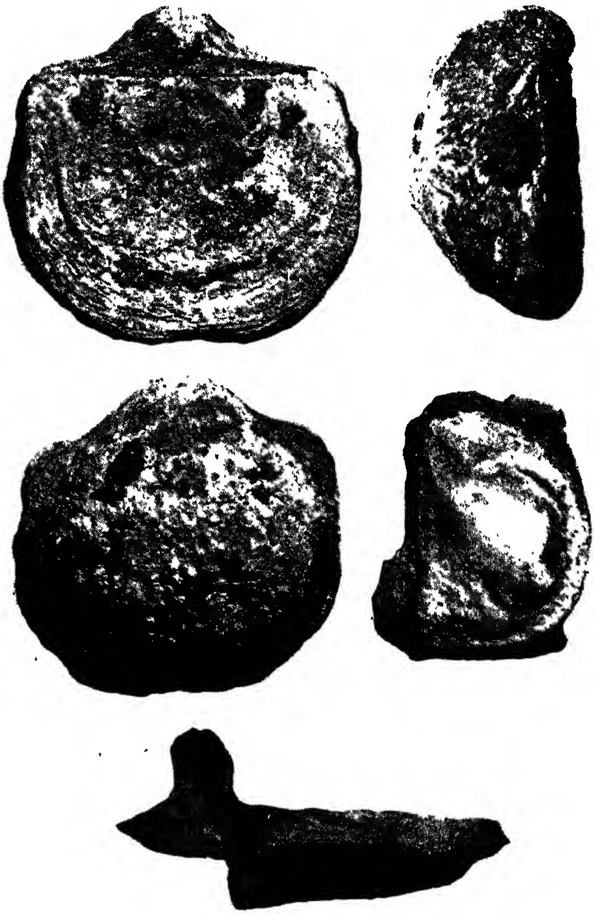
Locality, Por. 147, Parish of Branxton, County of Northumberland.

WYNDHAMIA VALIDA, Sp. nov.

Pl. II., figs. 1-5; Pl. III., figs. 4, 6.

Shell larger generally than *Wyndhamia dalwoodensis*, plano-convex and spinose. The spines are larger, coarser and more sparse than those of *Wyndhamia dalwoodensis*. The shell is ornamented with a few faint ribs, mainly on the marginal slopes.

A sinus can be seen on internal casts of the pedicle valve, but is largely obscured by the shell growth. The species may therefore be considered to be in a katagenetic condition. The hinge line is long, straight and nearly the full width of the shell, there is a well marked area in both valves, and the ears are well marked but without spines.



1 2 3 4 5

Figs. 1 – 5—*Wyndhamia valida,* Sp. nov.

The brachial valve is flat or slightly concave, and in this species is very thick in adult specimens. The teeth are exceptionally well developed and fit into deep sockets in the brachial valve. The septum of the brachial valve extends anteriorly for nearly two-thirds the length of the valve. The cardinal process is very large and strong, somewhat inclined, bifid anteriorly and markedly quadrified posteriorly. (Pl. II., fig. 5; Pl. III., figs. 4, 6.) The flabellate adductor muscle scars in the brachial valve are compact and cannot be differentiated into anterior and posterior elements. They are triangular in shape and practically identical with those of *Wyndhamia dalwoodensis.* The brachial supports are also identical with those of the type *Wyndhamia dalwoodensis.*

Locality, Por. 152, Parish of Branxton, County of Northumberland.

The subgenus *Wyndhamia* has been erected for the reception of shells resembling *Strophalosia clarkei* in outward appearance, but which have a well developed sinus in the pedicle valve, and which differ markedly from *S. clarkei* and from *Strophalosia* generally in the internal characters of the brachial valve.

For the purpose of a preliminary paper it will be sufficient to compare the new subgenus with *Strophalosia*, King, 1844, *Aulosteges,* von Helmerson, 1847, and *Productus* (*Tæniotherus*) *subquadratus,* Morris, 1845.

Wyndhamia is perhaps most nearly related to *Strophalosia clarkei,* Eth. Fil., particularly in size and general contour of the shell. The ornamentation of *Wyndhamia,* however, is decidedly coarser than that of *St. clarkei*, while

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[1] Etheridge, R., Junr., Proc. Roy. Phys. Soc. Edinburgh, Vol. 5, Pl. 9, fig. 21, 1880.

Specimen No. F2412, Mining Museum, Sydney.

internally the adductor muscle scars of the brachial valve of *St. clarkei* are distinctly differentiated into anterior and posterior elements, whereas those of *Wyndhamia* are undifferentiated. A deep sinus extending right to the umbo is characteristic of *Wyndhamia*, but *Strophalosia* generally is without a sinus, though *St. excavata*, Geinitz[2] has a sinus in the anterior part of the pedicle valve, and one of the specimens of *St. clarkei* examined (F2412, Mining Museum, Sydney) also had a slight sinus in the anterior part of the pedicle valve.

Etheridge[3] figures one specimen as *Strophalosia clarkei* which will almost certainly need to be referred to *Wyndhamia*.

The form of the brachial supports of *Wyndhamia* is similar to that of *Strophalosia jukesii*[4], but the distortion
Vol. 5, Pl. XIII, figs. 39-43, 1880.
of *St. jukesii* is such that one is never likely to have difficulty in separating the two.

There is absolutely no sign of distortion of the pedicle valve of either species of *Wyndhamia* due to its having at some stage of its existence been attached to some foreign body. This last character is used by Clarke[5] as a generic distinction between *Strophalosia* and *Productella*, Hall, 1847. The species under discussion, however, have little affinity with *Productella*, differing markedly from it in the characters of the cardinal process, teeth and muscular impressions. The brachial supports of *Wyndhamia* are

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[2] Waagen, W., Pal. Indica, Series XIII, vol. 1, p. 642, Pl. LXV, fig. 5, 1887.

[3] Etheridge, R., Junr., Proc. Roy. Phys. Soc. Edinburgh, Vol. 5, Pl. 9, fig. 23, 1880.

[4] Etheridge, R., Junr., Proc. Roy. Phys. Soc. Edinburgh,

[5] Hall and Clarke, Palaeontology of New York, Vol. VIII, part 1, p. 315, 1892.

strongly developed and very characteristic of the subgenus, while in *Productella* they are rarely retained (even if present.

Aulosteges, von Helmerson, is characterised by a convex, spike-like deltidium covered with tubercules or spinules, and by the teeth being either rudimentary or absent. *Wyndhamia*, on the other hand, has strongly developed teeth and sockets. The deltidium was only observed in one specimen which it was impossible to figure, but it seemed to be small and triangular, not spike-like as in *Aulosteges*, and it showed no signs of spines or tubercules. King[6] was not disposed to regard the spinose condition of the deltidium as of generic value, but the differences in the teeth and deltidium are sufficient to definitely separate *Wyndhamia* from *Aulosteges*.

Productus (*Taeniotherus*) *subquadratus*, Morris, was described and figured by Etheridge in 1880[7] and 1892.[8] In 1909 the species was redescribed and refigured by Etheridge and Dun.[9] They directed attention to the many characters which this species had in common with Aulosteges, but did not consider it to differ sufficiently from Productus to erect a new sub-genus or genus for its reception.

In 1926 Whitehouse[10] proposed the name *Taeniotherus sub-quadratus* for the species, but did not describe or

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[6] King, W., The Permian Fossils of England, printed for the Palaeontographical Society, 1850, p. 94.

[7] Etheridge, R., Junr., Proc. Roy. Phys. Soc. Edinburgh, Vol. 5, p. 283.

[8] ———, Geology, Palaeontology, etc., of Queensland, p. 252, Pl. 38, figs. 7-10; Pl. 40, fig. 5.

[9] Etheridge, R., Junr., and Dun, W. S., Records of the Geological Survey of New South Wales, Vol. VIII, part 4, p. 300, Pl. XLI, figs. 1-5.

[10] Whitehouse, F. W., Trans. Aust. Ass. Adv. Science, Perth, 1926, p. 281.

figure his types. It will be noted that *P.* (*Taeniotherus*) *subquadratus* is much the larger of the two. An area in both valves and compact dendritic adductor muscle scars in the brachial valve are features common to both. They differ considerably, however, in the form of the brachial supports, and the cardinal process of *Wyndhamia* is typically strophalosoid, while that of *P.* (*Taeniotherus*) *subquadratus* closely resembles *Productus* proper.

Wyndhamia must therefore be classed as one of the intermediate forms between *Productus* and *Strophalosia* and nearer to *Strophalosia* than *Productus*.

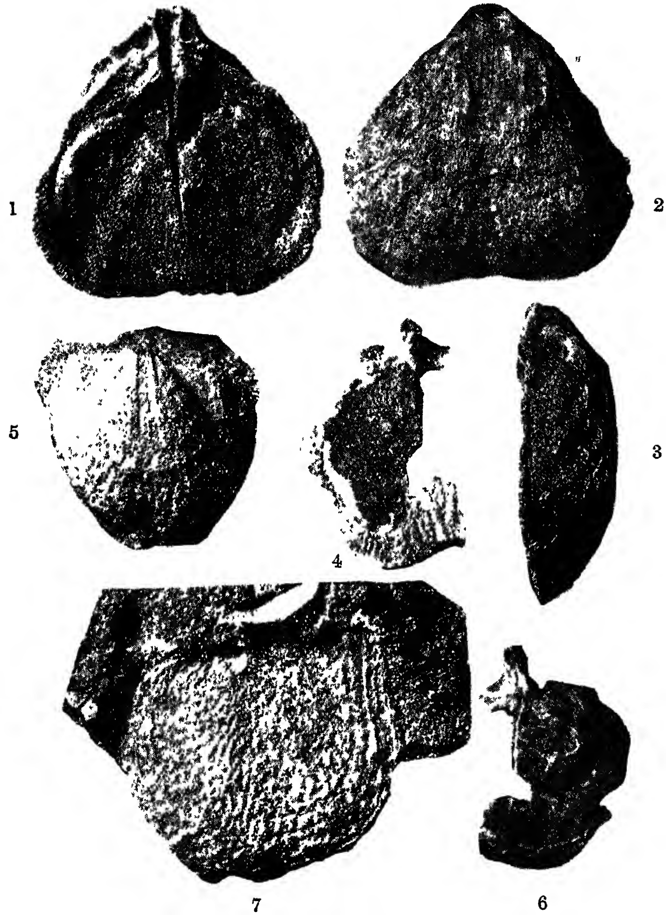
Genus—PRODUCTUS, Sowerby, 1812.

Subgenus—BRANXTONIA, Subgen. nov.

BRANXTONIA TYPICA, Sp. nov.

Pl. III., figs. 1-3.

Shell plano-convex and productoid in form. A well developed sinus is present in the pedicle valve. The hinge line is short and curved, and no ears are developed. The brachial valve is flat or slightly concave and no area is developed in either valve. Teeth are present, but are more or less rudimentary. The septum is very long and strongly developed and reaches nearly to the anterior margin of the shell. The cardinal process is somewhat inclined and bilobed posteriorly. The adductor muscle scars of the brachial valve are flabellate, compact, and not differentiated into anterior and posterior elements. They are triangular in shape, with one side parallel to the median septum, the apex directed posteriorly and the base raised considerably above the general level of the valve, forming a boss resembling that developed in the genus *Strophalosia*. The brachial ridges have their origin near the middle of the adductor scars and run sub-parallel to the margins of the shell to the antero-lateral edge, where they definitely terminate. (Pl. III., fig. 1.)



Figs. 1 - 3—*Branxtonia typica*, Sp. nov.
Figs. 4, 6,—*Wyndhamia valida*, Sp. nov.
Figs. 5, 7,—*Wyndhamia Dalwoodensis*, Sp. nov.

Type, Branxtonia typica, Sp. nov.

Locality, Portion 147, Parish of Branxton, County of Northumberland.

This species is represented only by three internal casts, but the characters are so marked that one has no hesitation in erecting, tentatively at least, a new subgenus for its reception. The species is most nearly related to Productus, but differs from that genus in having dental callosities developed, while the adductor scars of the brachial valve are remarkably like those of *Wyndhamia*. The affinities of the species cannot be further discussed without material showing the external appearance of the shell; an attempt will, however, be made to obtain such material for description in a future paper.

The two new subgenera described occur on the same horizon about 2,250 feet below the Muree Beds, in the Branxton Stage of the Upper Marine Series in the Hunter River District. The Branxton Beds and Muree Beds abound in productid types, a close examination of which may make it possible to divide these strata into zones of considerable stratigraphic value.

LIST OF PLATES.

PLATE I.

Fig. 1.—*Wyndhamia dalwoodensis.* A damaged internal cast showing one ear, and spines penetrating the matrix.

Fig. 2.—. . . . An internal cast showing the deep impressions of the teeth.

Figs. 3 and 4.—. . . . An internal cast of the brachial valve, and a mould made from it to show the disposition of the brachial supports, septum etc.

Fig. 5.—. . . . A mould of the brachial valve and part of the pedicle valve showing the area of both valves.

Figs. 6 and 7.—*Strophalosia gerardi.* A brachial valve showing the cardinal process, area and internal structures.

PLATE II.

Figs. 1-3.—*Wyndhamia valida.* A large specimen showing the shell structure and ornamentation.

Fig. 4.—. . . . Half of a brachial valve showing the brachial supports and muscle scar.

Fig. 5.—. . . . An enlarged view of the cardinal process and area, $\times$ 2.

PLATE III.

Figs. 1-3.—*Branxtonia typica.* Three views of an internal cast.

Figs. 4, 6.—*Wyndhamia valida.* Two views of a brachial valve showing the cardinal process and brachial support.

Fig. 5.—*Wyndhamia dalwoodensis.* An internal cast of a young specimen showing the sinus and ears.

Fig. 7.—. . . . Mould of a brachial valve showing ornamentation.

NOTES ON THE USE OF THE ANEROID BAROMETER AND PLANE TABLE IN GEOLOGICAL MAPPING.*

By H. G. Raggatt, B.Sc., and F. W. Booker, B.Sc.,
Geological Survey, Department of Mines.

(With Plates IV. to VI. and two Text Figures.)

(Read before the Royal Society of New South Wales, June 5, 1929.)

Since May, 1927, a modified form of the Barometric Method of Geological Surveying, described by Lahee,† has been used by the authors in the Singleton-Branxton area. The method has been used, chiefly, for the topographic work necessary for the preparation of a structure contour map of the area. The geology of most of the district had been previously worked out by the field party under Mr. Morrison, Geological Surveyor (of which the authors were members), but in certain areas geology and topography have been surveyed simultaneously.

One of the objects of this paper is to give Lahee's method wider notice in New South Wales, since it appears to be little known amongst local geologists. In its application by us, the method of correcting barometric readings, as suggested by Lahee, has been subject to very little modification, but its use in conjunction with the Plane Table for detailed mapping may be new, and in any case, a description of such a method should prove of interest to geologists.

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* Published with the permission of the Under-Secretary for Mines.

† Lahee, F. H.: "Economic Geology," Vol. XV., 1920, pp. 150-169. Day, David T., and others: "Handbook of the Petroleum Industry," Vol. I, 1922, pp. 183-191.

USE OF ANEROID BAROMETER.

Aneroid barometers are looked upon as unreliable instruments by many geologists, because there are too many inferior ones in use, and because a systematic method of correction has not been universally applied to the results obtained by their use.

There are in general four methods of checking barometric readings:—

(1) By means of the barograph.

(2) By observation of relative heights, instrumentally or otherwise.

(3) By internal checks, such as taking several readings at the same station over a known interval of time.

(4) By checking readings at points of known height, such as Trigonometrical stations and railway platforms.

It is not proposed to discuss these in detail, but several comments are offered.

The barograph may be useful in wide areas of fairly uniform topography, but its results are misleading in a district like the Hunter Valley, which is bounded by high Carboniferous hills to the north, and to the south by an escarpment bordering a plateau approximately 2,000 feet above sea level. The graph traced by a barometer stationed at Singleton is little or no use in correcting a set of readings obtained, say, at Broke or Dyrring. Each of these places experiences thunderstorms in the summer which Singleton usually escapes.

The second method is a decided aid in conjunction with Lahee's scheme, since points clearly visible from stations at which aneroid readings are taken may be included in the map. Possible inflection points, on the variation curve,

may also be detected by examining the movement of the barometer while noting approximately the true relative differences in elevation between points on a traverse. It sometimes happens, for instance, that the barometric reading may remain stationary during a period in which an obvious ascent has been made, or a rise may be shown between points which observation shows to be on the same level.

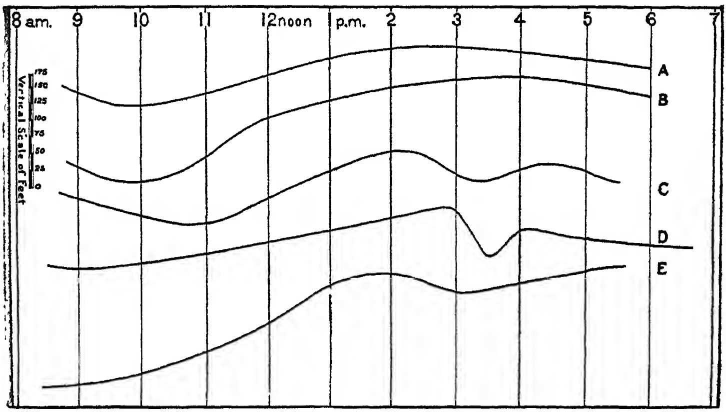

Fig. 1. Types of curves drawn to illustrate the need for a reliable method of correcting readings of the aneroid barometer.

Using the third method, the movement of the barometer may be checked by two or more readings at the same station over an interval of not less than twenty minutes,* by making an offset and returning through the station from which the offset was made, by closed traverses, and by passing through the same points twice or more during the same day.

By the fourth method the barometer reading is checked against stations of known height, not only giving an indi-

* While searching for fossils, for example.

cation of the movement of the instrument, but referring them to a fixed datum.

The third and fourth methods are commonly used by geologists, and it is with the systematic and accurate application of these to the correction of readings of the aneroid barometer that Lahee's method is chiefly concerned.

The need for a reliable and systematic method of correcting readings of the aneroid barometer is shown by the diversity in the form of the curves in Fig. 1.

The curve A is fairly typical of a spring day in the Hunter Valley. B, C, D and E are curves obtained for four consecutive days in May, 1927. A thunderstorm occurred at 3.35 p.m. in D. It may be noticed that E represents approximately the average of the three preceding stages. These curves show that the results obtained on one day cannot be carried forward to the next without introducing appreciable error, and that the method of allowing so much per hour over the day's readings would also lead to unreliable results. Columns 1, 2 and 3 in the following table give some of the results obtained in a traverse,* in the vicinity of Branxton, on the 28th August, 1928. Column 4 gives the elevation of points of known height, one of which is obtained from another traverse.

The curve to be used in correcting readings of the barometer is obtained by plotting elevations in feet as ordinates and times of abscissae.

Using squared paper labelled as convenient a choice of origin will, of course, be made such that the curve will be conveniently situated on the graph paper. The station chosen as headquarters at the time of the traverse described

* At this stage the method by which the traverse may have been made is not considered.

herein was made, is nearly the lowest point in the area. Consequently a point near the lower left hand corner of the squared paper was selected as origin.

Station.	Time.	Barometer Reading.	Known Heights.	Corrected Readings.
Base	8.30	705	90	—
Black Ck. Bridge ..	9.00	710	—	130
R55	9.15	750	—	175
R54	9.15	850	275	—
R46	9.20	760	—	185
R45	9.20	850	—	275
R40	9.50	810	—	235
R46	10.20	760	—	185
Black Ck. Bridge ..	10.40	715	—	130
Overhead Bridge, Branxton	10.55	740	152	—
Br. 61	11.50	880	—	255
Branxton R'lway Stn.	12.30	795	137	—
Br. 62	12.50	795	—	120
Br. 62	2.00	840	—	120
Br. 63	3.00	920	—	190
Br. 54	3.20	1005	—	275
Br. 64	3.45	970	—	245
Br. 65	3.50	945	—	220
Br. 66	4.00	1050	—	325
Br. 67	4.10	1000	—	280
Br. 68	4.30	955	—	235
Base	5.00	800	90	—

Fixed points on the curve are obtained by plotting the algebraic difference between the aneroid readings in feet and the actual elevation of points of known height. Fixed points on the curve in Fig. 2 are A, B, C and D, representing (705—90), (740—152), (795—137) and (800—90) respectively. (See columns 3 and 4.)

The trend of the curve between the fixed points is obtained by using lines known as guide lines. For instance, at station Br. 62, the barometer reading in feet rose from 795 at 12.50 to 840 at 2.00 p.m. The guide line LM illustrates this. The points L1 and M1 on the correction curve correspond to the points L and M on the guide line. Obviously LM is not related to any horizontal datum.

It is important to note that the curve is not necessarily parallel to the guide lines. The latter are drawn on the graph simply for the convenience of reference, the only

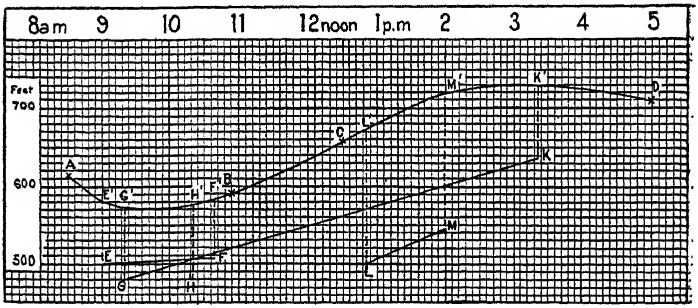

Fig. 2. Graph illustrating method of drawing a Correction Curve.

essential relation between the two being that points on the correction curve lying on the same abscissae as the ends of the guide lines shall be similarly related in vertical difference. Thus K is the same height above G as K1 is above G1, but the curve nevertheless has an inflection point between G1 and K1 which is determined by other data.

Having drawn the curve, corrections are applied to the readings of the aneroid barometer as follows:—Note the time at which a given reading was taken and read from the graph the ordinate (feet) of the point on the

curve for which the given time is the abscissae. Subtract this amount from the reading of the aneroid barometer at the given time, for the point in question, and the result is the required corrected height of the point in feet. For example, at 3.50 p.m. the barometer read 945 at station Br. 65. The ordinate of a point which has 3.50 as its abscissae is 725. The required figure is therefore 945 minus 725, that is, 220 feet.

We have found the method to be quite as accurate as Lahee claims it to be. The following check was applied.

Using the railway stations Branxton, Belford, Minimbah, Whittingham and Singleton, and such trigonometrical stations as were available as fixed points, traverses were made, which crossed the Great Northern Railway at a number of places. The contours based on these traverses were then compared with the working section in the Railway Department, which gives a profile section along the permanent way. The result was highly satisfactory. In the parish of Belford contour lines drawn at intervals of fifty feet cross or come very close to the railway about seventeen times. In one place the error was twenty feet. In four other places the contours required very slight modification. There were no other appreciable errors. The contours were drawn on a base map with a scale of one inch equal to twenty chains. It is evident that when the map is reduced to half this scale the errors mentioned will scarcely be reflected in the structure contours based upon them.

Plane Table Traversing and the Barometric Method.

The barometric method may be used in conjunction with any of the recognised methods of traversing. It is essential, however, that readings of the barometer should be systematically recorded, and be easily referable to stations

indicated on the map. For these reasons we have found the profile (Campbell) method and the tabulation method of recording observations unsatisfactory when used by themselves. We consider that there is not enough space available on each page of a field notebook, using either method. Further, in the topographic base map of a geological survey, observations are best recorded permanently at the time they are made. The course of a stream plotted from prismatic compass traverses cannot possibly be as accurately traced as if it were indicated on a plane table in the field.

The scheme adopted by us has been to combine plane table traversing with the tabulation method of note taking. This was possible because the greater portion of the area had been subdivided and cleared of thick forest. The area was also fairly well known to us before topographic work was commenced. The following is a brief description of the method.

Two heliographs of each of the parish maps (scale, one inch equals twenty chains) over which work is to be done are obtained from the Department of Lands. One of each of these is cut into rectangles twelve inches by eight inches, each rectangle being mounted on linen which has previously been covered with white paper. The mounting is done in such a way as to leave a white margin of about one inch around the map rectangle. These sheets are then ready for field work. (Plate IV.)

The plane table used measured fourteen inches by twelve inches. This size was found to be quite large enough for use with a sight rule twelve inches long.*

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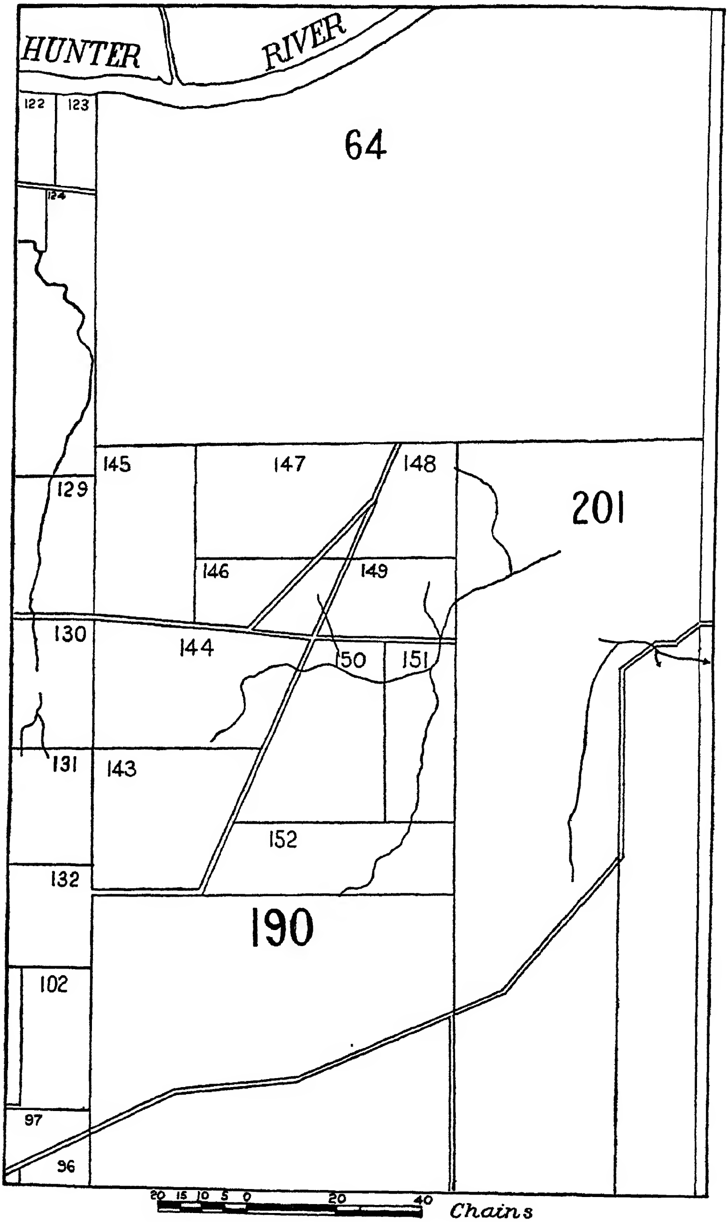
* One of the reasons why the "sight and pacing" method as described below was used by us was that we could not expect to achieve accuracy by intersection and resection with the apparatus available.


HUNTER
RIVER
122
123
64
124
145
147
148
201
129
146
149
130
144
150
151
131
143
152
132
190
102
97
96
20 15 10 5 0 20 40
Chains

The plane table is set up in the usual way at a known point, station number, aneroid reading and time noted in a field book (vide table, page 37), the station number marked on the map, and the topography sketched on the plane table. As work proceeds, geological notes are also made in a separate field book and referred to the station at which they are prepared. Station numbers are allotted consecutively, prefixed by the first letter or letters of the name of the parish in which the traverse is made. (For instance, B1, the first station in Belford; BR2, the second station in Branxton.) This system makes for convenience of reference in drawing the correction curve subsequently. If the first station (or any subsequent station) is situated on a portion boundary fence, say, about half a mile long, which trends in such a way as to traverse a number of natural features, it may be followed, the plane table being set up at intervals and the topography sketched, using the alidade freely for intermediate points close to the traverse. If the station is not thus conveniently situated, a sight is taken in the usual way with the alidade and a line drawn on the map.

Distances are measured by pacing, using an ordinary sheep tally for counting. Prior to the commencement of a traverse, a pencil line is drawn down the middle of the most convenient white margin surrounding the map rectangle. The number "O" is entered at the bottom of the left-hand of the two columns so formed, and at each subsequent station the number shown by the tally entered in turn. The distance between stations is then given by a series of subtractions, the results of which are entered at the right-hand column.

If an error in plotting should occur there is thus a permanent record of the distance between stations which will enable the error to be located.

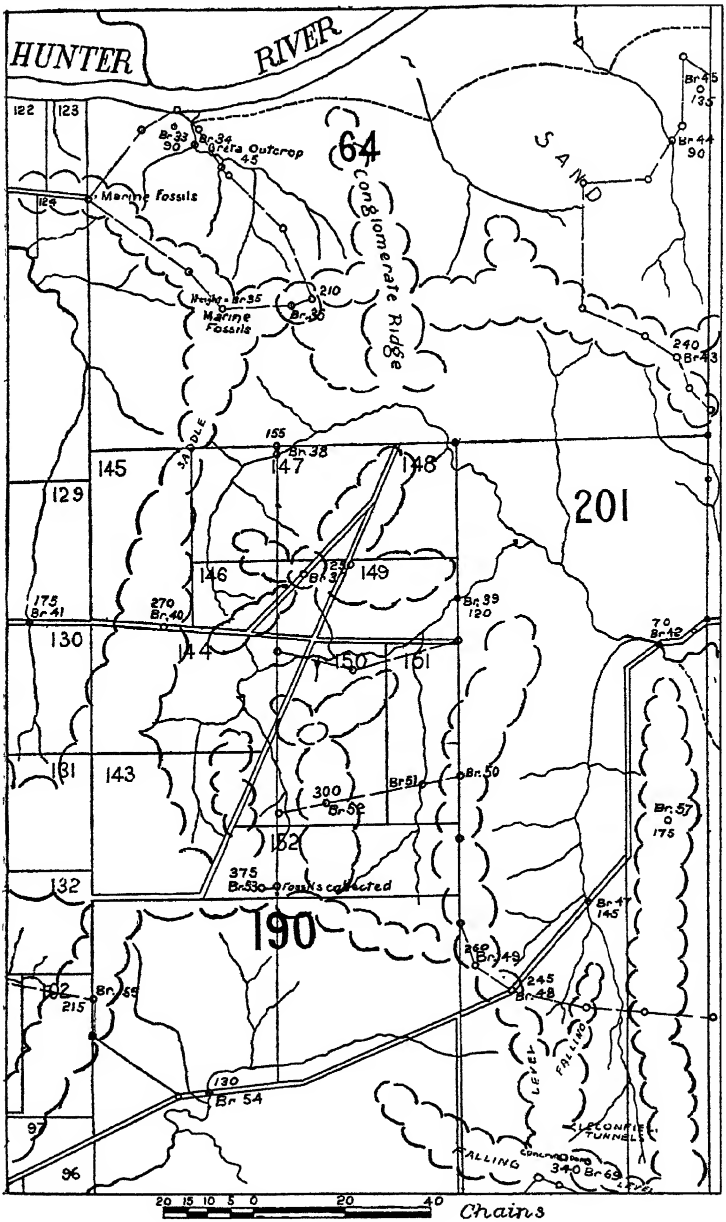
A note may be added in reference to pacing and plotting generally. Many geologists count their paces, checking each hundred in some way with the fingers. They then convert paces to chains and plot the distance. It will be found easier, quicker and more accurate to use a sheep tally, or any other automatic counting device, depressing the lever at every second pace, and plotting the numbers given by the instrument as units of distance. For instance, assuming pacing at the rate of 25 paces to the chain, using this method, and commencing from zero, the tally will show 50 at the end of four chains. Assume the scale of the map to be one inch equals twenty chains, i.e., one-tenth of an inch equals 25 units on the tally. It is much easier and quicker to plot the two-tenths directly than to convert 100 paces to chains first. The advantages will become more apparent if a number which is not a multiple of five be selected.

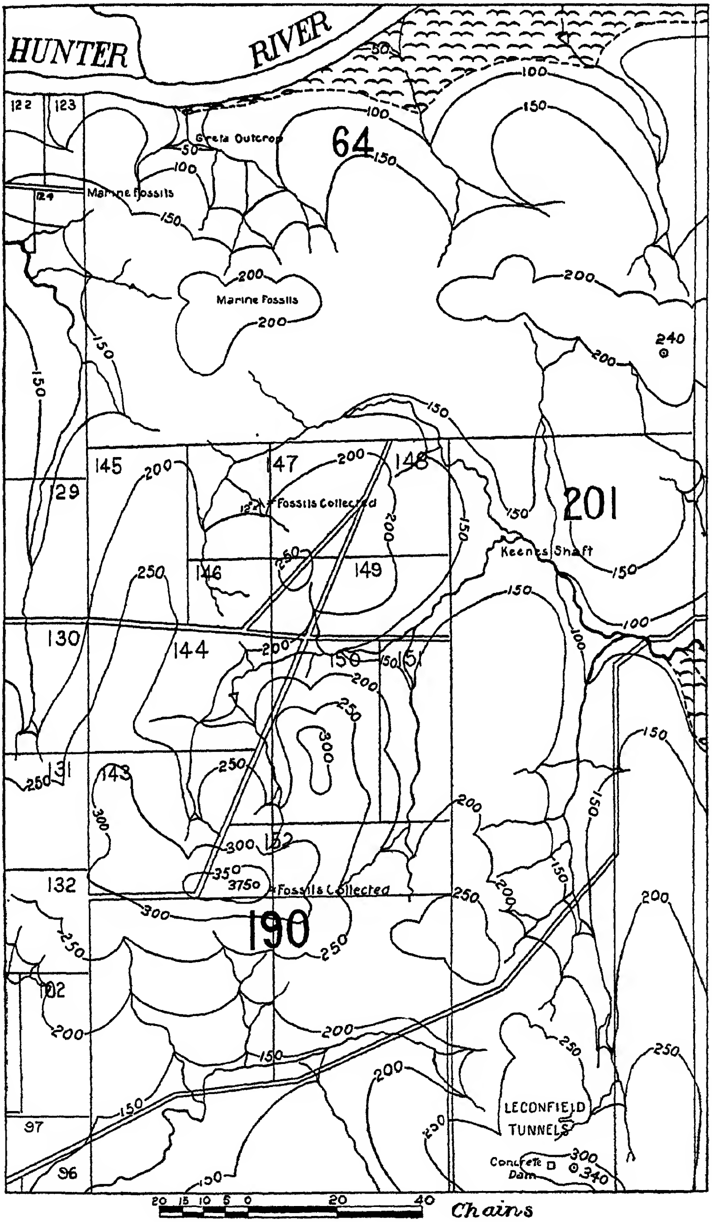
With a pacing error not exceeding four per cent., and frequent checks at portion corners, the traverse should require no correction.

Hill features are shown by form lines, to assist in drawing the contours after the correction curves have been applied to the barometer readings. Plate V shows a map rectangle as completed in the field.*

After the aneroid readings have been corrected and the contour lines drawn on the field map, they are transferred to the uncut office map. All the information required on the final map is also inked in and the map washed in dilute oxalic acid. This removes all stains caused by patches in the original tracing, names of portion holders' acreages, and other marks or notes which not only are not

* Except that the record of numbers on the white margin has been omitted.


HUNTER RIVER
SAND
Conglomerate Ridge
Marine fossils
Greta Outcrop
Marine Fossils
SADDLE
fossils collected
LEVEL
FALLING
Chains


HUNTER RIVER
Greta Outcrop
Marine Fossils
Marine Fossils
Fossils Collected
Keenes Shaft
Fossils Collected
LECONFIELD TUNNELS
Concrete Dam
64
201
190
240
340
20 15 10 5 0 20 40 Chains

required on the final map, but which may obscure essentials if allowed to remain. The result is a clear map with only such information as has been marked in Indian ink remaining. (Plate VI.)

It has seemed to the authors desirable to keep this paper as short as possible. It is assumed that anyone reading these notes is familiar with the technique of geological surveying, but if not, the above information may be supplemented by reference to any one of the many publications on the subject.

EXPLANATION OF PLATES.

Plate IV.—Facsimile of plane table sheet before commencement of traverse.

Plate V.—Facsimile of plane table sheet as completed in the field, and with corrected heights of stations indicated. Traverse shown by broken lines, except where subdivision fences have been followed. Stations shown by circles, numbered where aneroid readings were noted.

Plate VI.—Facsimile of completed office map corresponding to plane table sheet in Plates IV. and V.

NOTE.—Owing to overlapping of traverses on various sheets, it was not practicable to give the notes and corrections curves corresponding to the plane table sheet illustrated.

THE CELLULOSES OF SOME AUSTRALIAN PLANTS.

By WILLIAM GERHARD ARNEMAN and
JOHN CAMPBELL EARL, D.Sc., Ph.D.

(Read before the Royal Society of New South Wales, June 5, 1929.)

The opinion has been expressed (Heuser, Zeitschrift für angewandte Chemie, 1921, *34*, 461) that celluloses from all sources are probably identical, and there is no doubt that the same view is widely held by other workers in the field of cellulose chemistry. The isolation of an abnormal cellulose from posidonia fibre, previously recorded by one of us (Journal of the Chemical Society, 1924, *125*, 1322), appears to be irreconcilable with this view. Posidonia cellulose, prepared by the usual chlorination method from posidonia fibre, yields a triacetate having an optical rotation ($[\alpha]_D$ = —39.8°, in chloroform) nearly double that of cotton cellulose triacetate ($[\alpha]_D$ = —22.3°). This abnormality has been confirmed by numerous independent observations, control experiments on cotton cellulose with the same reagents being carried out in each case.

The unsupported evidence of the exceptional nature of posidonia fibre cellulose would hardly justify a refutation of the generally accepted view of the identity of celluloses from all sources. A search was undertaken, therefore, among a wide range of Australian plants, to ascertain whether any other exceptional cellulose could be discovered.

Isolation of Celluloses.

The isolation of the cellulose from the plant material was effected by the well-known chlorination method of Cross and Bevan. The modification was introduced, however, of alcohol (cf. Cross and Bevan, J. Chem. Soc., 1889, *55*, 205), instead of sodium sulphite solution, the extracting agent usually employed. If necessary, the chlorination and extraction were repeated until a pure white product was obtained. In the case of posidonia fibre, a preliminary treatment with 2 per cent. sulphuric acid was applied to remove the pentosans, which otherwise might partly survive the chlorination treatment (Earl, J. Chem. Soc., 1923, *123*, 3223). The preliminary acid treatment was not employed in the case of posidonia leaves or any other of the fibrous materials examined.

Acetylation.

For this purpose the procedure devised by Barnett (J. Soc. Chem. Ind. 1921, *40*, 8T) was employed. The acetyl content of acetate prepared by this method corresponds approximately to that of a cellulose triacetate (cf. Irvine and Hirst, J. Chem. Soc. 1922, *121*, 1588; Earl, J. Chem. Soc. 1924, *125*, 1323). Individual determinations were not made in each case under review. The application of the method under somewhat varying conditions, although it might affect the acetyl content, has little effect on the optical rotation of the product, as the following results obtained for cotton cellulose show:—

Duration of heating.	Maximum temperature.	$[\alpha]_D$
1 hour	70° C.	—23.6
2 hours	70° C.	—21.7
2 hours	85° C.	—22.7

Comparison of Celluloses.

The celluloses examined were selected over as wide a range as possible, and included wood cellulose, celluloses

of water plants (some of which, in the absence of suitable material, could not be identified botanically), and finally the cellulose of the salt bush (Atriplex vesicarium), as exemplifying a cellulose formed under saline conditions.

The results are summarised in the following table:—

	Source of Cellulose.	$[\alpha]_D$ of acetate.
Water Plants	Posidonia fibre	—39.9°
	Posidonia leaves	—39.9°
	Cymodocea sp.	—22.0°
	Potamogeton sp.	optically inactive
	Unknown (possibly Zostera sp.)	—22.2°
Woods	Doryphora sassafras	—22.6°
	Araucaria Cunninghamii ..	—22.6°
Saline Plant	Atriplex vesicarium	—20.1°

The conclusion to be drawn from the above results is that the accepted view of the identity of all celluloses must be viewed with suspicion if not entirely rejected. On the other hand no explanation of the differences shown can be offered at present; work in this direction is proceeding. The remarkable result recorded for Potamogeton is based on the examination of one sample only, and requires confirmation and closer examination before its full bearing on the general cellulose problem can be determined.

The author's thanks are due to the former Curator (Mr. Hooper) and the Economic Botanist (Mr. M. B. Welch) of the Technological Museum for the supply of authentic wood specimens, and to Professor Osborn for supplies of saltbush and for his kindness in identifying several of the plants examined.

AN EXTENSION OF THE CONCEPTION OF THE DISTRIBUTION COEFFICIENT.

By IAN WILLIAM WARK, D.SC., PH.D.

(Communicated by Professor C. E. Fawsitt, D.Sc., Ph.D.)

(Read before the Royal Society of New South Wales, July 3, 1929.)

It is the purpose of this communication to develop a general thermodynamic treatment of physico-chemical equilibria based upon an extended conception of the distribution process. Initially relations for the change of distribution coefficient with pressure and temperature are deduced; in the sequel these are applied in a systematic manner to various types of equilibria in order to obtain relations showing the effect of changes in temperature or pressure on such equilibria. A generalised form of the clapeyron equation is deduced. The gain in the generality of treatment may be of help to the student of thermo-
Clapeyron equation is deduced. The gain in the generality
ciples of the Phase Rule.

Throughout the paper, the notation of Lewis and Randall is employed, and, at the outset, the author would like to acknowledge his indebtedness to their treatise on thermodynamics* and also to van't Hoff's "Lectures on Theoretical and Physical Chemistry."

* Thermodynamics and the Free Energy of Chemical Substances (New York, 1923).

Section A.—Variation of Distribution Coefficient with Temperature and Pressure.

Let the component X be distributed between the two phases I and II such that its activities in these phases are $[a_X]_I$ and $[a_X]_{II}$ respectively.

Then, if k be the distribution coefficient,

$$k = [a_X]_{II} / [a_X]_I$$

But (see Lewis and Randall (l.c.), p. 255)

$$RT \ln [a_X]_I = \overline{F}_I - F_I^\circ \quad \ldots \quad (1)$$

$$\text{and } RT \ln [a_X]_{II} = \overline{F}_{II} - F_{II}^\circ \quad \ldots \quad (2)$$

where $\overline{F}_I$ and $\overline{F}_{II}$ are the partial molal free energies of the component X in the two phases, and F_I° and F_{II}° are the corresponding values for X in its standard state in each of the two phases.

Since the phases are in equilibrium, $\overline{F}_I = \overline{F}_{II}$ and subtracting (1) and (2), we see that

$$RT \ln [a_X]_{II} / [a_X]_I = -(F_{II}^\circ - F_I^\circ)$$

$$\text{i.e., } RT \ln k = -\Delta F^\circ \quad \ldots \quad (3)$$

where ΔF° is the gain in free energy in transferring one mol of X from its standard state in the phase I to that in phase II.*

(a) *Temperature Variations:—*

Differentiating equation 3 with respect to temperature, pressure being constant,

$$\left(\frac{\delta \ln k}{\delta T}\right)_R = -\left(\frac{\delta(\Delta F^\circ/RT)}{\delta T}\right)_P = \frac{\Delta H}{RT^2} \quad \ldots \quad \ldots \quad (4)$$

(See Lewis and Randall, p. 173, for proof of this transformation.)

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* Note the resemblance to the general equation for the equilibrium constant,

$$RT \ln K = -\Delta F^\circ, \text{ (L. \& R., p. 294).}$$

where ΔH is the gain in heat content characteristic of transferring one mol of X from its standard state in phase I to that in phase II. This equation is identical in form with the well-known van't Hoff isochore. Applications of equation (4) are given in an appendix to this paper.

(b) *Pressure Variations*:—

Differentiating (3) with respect to pressure, temperature remaining constant,

$$\left(\frac{\delta \ln k}{\delta P}\right)_T = -\frac{1}{RT}\left(\frac{\delta \quad \Delta F^\circ}{\delta P}\right)_T = -\frac{\Delta V}{RT} \quad \dots \quad (5)$$

where ΔV is the change in partial molal volume upon transferring one mol of X from its standard state in phase I to that in phase II.

(See L. and R., p. 204, for proof of this transformation.)

(c) *Generalised Clausius-Clapeyron equation*:

Since k is a function of P and T alone, we have the relation

$$\left(\frac{\delta P}{\delta T}\right)_{\ln k} = -\left(\frac{\delta \ln k}{\delta T}\right)_P \Big/ \left(\frac{\delta \ln k}{\delta P}\right)_T$$

or substituting for the last two terms, from equations (4) and (5)

$$\left(\frac{\delta P}{\delta T}\right)_{\ln k} = -\frac{\Delta H}{T\ \Delta V}$$

This expression shows how the external pressure must be made to vary with the temperature if there is to be no variation in distribution coefficient, i.e., for all practical purposes, if there is to be no change in the equilibrium. The relation is a generalised form of the Clausius-Clapeyron equation; it applies for the "equilibrium constant" equally well.

Physical and Chemical Equilibria.

The similarity to the corresponding expressions for the chemical equilibrium constant, K, is not surprising. For

thermodynamics takes no cognisance of the distinction, drawn for convenience, between "chemical" and "physical" changes. In fact it is possible to regard all "chemical" changes as cases of distribution and to derive the equilibrium conditions on this assumption. Thus in the closed system containing no components other than those indicated by the equation, $CaCO_3 = CaO + CO_2$, we may regard the CO_2 as being distributed between the gaseous and the two solid phases, just as iodine is shared between water and carbon tetrachloride when a gaseous phase is also present. The dissociation of calcium carbonate is in accord with precisely the same laws as the iodine distribution. There is, however, one important distinction, namely, that the miscibilities of the phases are more restricted, being confined to certain narrow limits. Of course cases are known which cover all ranges of miscibility and it is the function of chemistry to investigate the causes of variations in miscibility, whereas, as pointed out above, thermodynamics is not concerned with the causes of solution, but merely with the phenomena which have been observed.

SECTION B. SYSTEMATIC APPLICATION OF THE DEDUCTIONS OF SECTION A.

I.—ONE COMPONENT SYSTEMS.

(a) Liquid-Vapour Systems.

The component is regarded as distributed between the liquid and gaseous phases.

$$k = \frac{a_{vap.}}{a_{liquid}}$$

where $a_{vap.}$ is the activity of the component in the vapour phase, etc.

But $a_{liq.}$ is taken as unity, i.e., the liquid is chosen as the standard state (L. and R., p. 256), and hence $k = a_{vap.}$, or a liquid possesses a fixed vapour pressure.

Temperature Changes.—By equation (4) of Section A,

$$\left(\frac{\delta \ln k}{\delta T}\right)_P = \left(\frac{\delta \ln a_{vap.}}{\delta T}\right)_P = \frac{\Delta H}{RT^2}$$

ΔH being the molal heat of condensation.

Now $a_{vap.}$ is approximately equal to the vapour pressure, p. Hence

(i) ... ... $\left(\frac{\delta \ln p}{\delta T}\right)_P = \frac{\Delta H}{RT^2}$ (c/p. L. and R., p. 185.)

an expression which shows how the vapour pressure of a liquid varies with the temperature. (For the integration of this equation, see van't Hoff's lectures.)

Pressure Changes.—By equation (5) of Section A,

$$\left(\frac{\delta \ln k}{\delta P}\right)_T = \left(\frac{\delta \ln a_{vap.}}{\delta P}\right)_T = -\frac{\Delta V}{RT}$$

and, as above,

(ii) ... ... $\left(\frac{\delta \ln p}{\delta P}\right)_T = -\frac{\Delta V}{RT}$

ΔV being the molal change of volume on condensation. (Cp. L. and R., p. 185, in which the volume of the liquid is neglected, with the result that V in their equation replaces ΔV in ours.)

Corollary.—Since $\left(\frac{\delta \ln p}{\delta T}\right)_P = \frac{\Delta H}{RT^2}$

and further pv = RT where v is the molal volume in the vapour phase, $\left(\frac{\delta \ln p}{\delta T}\right)_P = \frac{\Delta H}{p\,v.T.}$

(iii) ... ... i.e. $\left(\frac{\delta p}{\delta T}\right)_P = \frac{\Delta H}{v.T}$

the usual approximation to the Clapeyron equation.

(b) Solid-Vapour Systems.

The component is distributed between the two phases such that

$$k = \frac{a_{vap.}}{a_{solid}}$$

In a manner precisely similar to the above, it may be shown that the relations (i), (ii) and (iii) of sub-section (a) again apply. (In this case the solid state has been selected as the standard state.)

(c) Liquid-Solid Systems.

As before, $K = \frac{a_{solid}}{a_{liq.}}$. The liquid state being taken as standard, this becomes $k = a_{solid}$

Temperature Variations.—By equation (4), Section A,

$$\left(\frac{\delta \ln k}{\delta T}\right)_P = \left(\frac{\delta \ln(a_{solid})}{\delta T}\right)_P = \frac{\Delta H}{RT^2}$$

This relation is of great use in the determination of activity from freezing points (L. and R. p. 282).

Pressure Variations.—By equation (5), Section A,

$$\left(\frac{\delta \ln k}{\delta P}\right)_T = \left(\frac{\delta \ln a_{solid}}{\delta P}\right)_T = -\frac{\Delta V}{RT}$$

showing how the activity of the solid phase varies with change of pressure. (ΔH and ΔV are the molal heat of fusion and the molal change of volume on fusion respectively.)

(d) Solid-Solid Systems.

In this case $k = \frac{a_{II}}{a_I}$, where a_{II} and a_I refer to the activity of the component in the solid phases II and I respectively.

Temperature Variations.—From the relation,

$\left(\frac{\delta \ln k}{\delta T}\right)_P = \frac{\Delta H}{RT^2}$, where ΔH is the molal heat of *transition* at the temperature T and pressure P, we derive the relation

$\left(\frac{\delta \ln a_{II}}{\delta T}\right)_P = \frac{\Delta H}{RT^2}$ if the activity of the component in the phase I be taken as unity at the temperature and pressure considered.

Pressure Variations.—Likewise,

$$\left(\frac{\delta \ln a_{II}}{\delta P}\right)_T = -\frac{\Delta V}{RT},$$ where ΔV is the molecular volume change at transition.

Dependence of Transition Temperature upon Pressure.—Finally $\left(\frac{\delta P}{\delta T}\right)_k = \frac{\Delta H}{T\Delta V}$, showing how the transition temperature depends upon the pressure.

From these equations it will be seen how the activity of one solid phase at any given temperature and pressure can be calculated, from the data of transition at that temperature and pressure, in terms of another solid phase as standard substance. In the preceding sub-sections it has been shown how to calculate the activity of the solid phase from the data of fusion, and also that of the vapour phase from the data of vaporisation, both in terms of the activity of the liquid phase. Hence it is possible to estimate the values of the activity of a substance in any state in terms of some one standard state—an important practical point.

II.—Two or More Component Systems.

For a two component system there are two sets of equations to be considered—one set for each of the components. The partial molal quantities $\overline{V}_1$, $\overline{V}_2$; $\overline{H}_1$, $\overline{H}_2$; etc. replace the quantities V, H, etc. of the previous sections. Generally it will be necessary to consider the relations for one component only; those for the second component are exactly similar. For a three component system there is a third set of relations which are precisely similar to those for a two component system, and so on for a four component system, etc.

(a) **Liquid-Vapour Systems.**

For component A, the distribution coefficient,

$k_1 = \dfrac{(a_1)_{vap.}}{(a_1)_{liq.}}$; $(a_1)_{vap.}$ being the activity of component A in the gaseous phase. Each of the components must be regarded as being shared between the liquid and gaseous phases and consequently there is a second coefficient,

$k_2 = \dfrac{(a_2)_{vap.}}{(a_2)_{liq.}}$ for the component B, and corresponding equations for C, D, etc. The activity of the components in the liquid phase is no longer dependent only on temperature and pressure, but depends also on concentrations.

Temperature Variations.—Now $\left(\dfrac{\delta \ln k_1}{\delta T}\right)_P = \dfrac{\Delta\overline{H}_1}{RT^2}$,

where $\Delta\overline{H}_1$ is the partial molal heat of condensation of the component A at the particular temperature, pressure, and concentration under consideration.

Consequently, $\left[\dfrac{\delta\,[\ln (a_1)_{vap}/(a_1)_{liq}]}{\delta T}\right]_P = \dfrac{\Delta\overline{H}_1}{RT^2}$,

If we restrict ourselves to constant composition* we may take the activity of the component A in the liquid phase as unity. (It is possible to find how this activity itself depends upon that of the pure liquid component A; hence we do not lose in generality by so choosing the standard.)

Hence $\left(\dfrac{\delta \ln f_1}{\delta T}\right)_{P,C} = \dfrac{\Delta\overline{H}_1}{RT^2}$, f_1 being the fugacity of the component A in the gaseous phase.

Or, approximately, $\left(\dfrac{\delta \ln p_1}{\delta T}\right)_{P,C} = \dfrac{\Delta\overline{H}_1}{RT^2}$, p_1 being the partial pressure of A.

* Perschke (Z. anorg. u. allg. Chemie, 151, 126, 239) has shown that k varies with concentration.

Pressure Variations.—As before, we may take $(a_1)_{liq.}$ as unity, whence approximately,

$$\left(\frac{\delta \ln p_1}{\delta P}\right)_{T,C} = -\frac{\Delta \overline{V}_1}{RT}$$

a relation which shows how the partial pressure of component A varies with the external pressure, the temperature and concentration, C being fixed.

(b) Vapour-Solid Systems.

The relationships are identical with those considered under (a).

(c) Liquid-Liquid Systems.

As in (a) $\left[\frac{\delta \ln (a_1)_I}{\delta T}\right]_P - \left[\frac{\delta \ln (a_1)_{II}}{\delta T}\right]_P = \frac{\Delta \overline{H}_1}{RT^2}$

where $(a_1)_I$ and $(a_1)_{II}$ are the activities of the component A in the two liquid phases. For dilute solutions we may take $(a_1)_{II}$ as being approximately constant in the phase rich in A and regard $(a_1)_I$ as a measure of the solubility of A in B. We thus arrive at the relation for a change in solubility with temperature of one liquid in another, namely, $\left(\frac{\delta \ln s_1}{\delta T}\right)_P = \frac{\Delta \overline{H}_1}{RT^2}$, s_1 being the solubility of A in the phase rich in B.*

A similar relation is easily deduced to show the effect of pressure on solubility, viz. $\left(\frac{\delta \ln s_1}{\delta P}\right)_T = -\frac{\Delta \overline{V}_1}{RT}$

* This equation breaks down if association occurs in one phase. If we retain $(a_I)_I$ in place of s_1 the relation is, however, still true, for the concentration in this case is not even approximately proportional to the activity but to some simple function of it. If the degree of association be known, the concentration can, of course, be approximately calculated from the activity. It should be remembered that thermodynamics takes no cognisance of the actual state of any phase at all, and that its rigorous equations apply to activities or thermodynamic concentrations and not to the ordinary stoichiometric concentrations.

Corollary.—At the critical solution temperature $k_1=k_2=1$. Consequently $\Delta\overline{V}_1 = \Delta\overline{V}_2 = \Delta\overline{H}_1 = \Delta\overline{H}_2 = 0$.

(d) Liquid-Solid Systems.

Temperature Variations.— $\left(\frac{\delta \ln k_1}{\delta T}\right)_P = \frac{\Delta\overline{H}_1}{RT^2}$, where $k_1 = \frac{(a_1)_{liq.}}{(a_1)_{solid}}$. In discussing this class of equilibrium, it is customary to regard the solid phase as consisting of one only of the components unless it has been specifically demonstrated that solid solutions may occur.

That the distribution law applies to cases where mixed crystals are formed has been shown by the work of van Bylert (Zeitschr. f. Phys. Chem. **8**, 343), who showed that the amount of thiophene crystallising along with benzole (C_6H_6) is directly proportional to its concentration in the liquid phase, and that of Beckmann and Stock (l.c. **17**, 120; **22**, 609), who showed that the system iodine-benzole also conforms to it. Possibly all such equilibria belong to this class. (Rivett, The Phase Rule, London, 1923, p. 8; Taylor, J.C.S., 1924, **125**, 1969.)

Nevertheless it is of interest to consider for a moment the case in which the amount of the component B in the solid phase is zero or so small that it may be neglected.

Then since $\left(\frac{\delta \ln(a\ )_{solid}}{\delta T}\right)_P = 0$

$$\left(\frac{\delta \ln(a_1)_{liq.}}{\delta T}\right)_P = \frac{\Delta\overline{H}_1}{RT^2}$$

Or, for dilute solutions, s being the "solubility" of A and ΔH its heat of solution, we derive the well-known expression for the solubility of A in B, $\frac{\delta \ln s}{\delta T} = \frac{\Delta H}{RT^2}$

Corollary.—Van't Hoff's Law of the Lowering of the Freezing Point. In like manner we have for a dilute solution of B in A $\left[\frac{\delta \ln (a_2)_{\text{liq.}}}{\delta T}\right]_P = \frac{\Delta \bar{H}_2}{RT^2}$

But (Lewis and Randall, p. 268)

$$d\ln (a_2)_{\text{liq.}} = -\frac{N_1}{N_2} \, d\ln (a_1)_{\text{liq.}}$$

where N_1 and N_2 are the molal fractions of A and B respectively in the liquid phase.

Further, in dilute solutions, a_1 is approximately equal to N_1. We thus have $-\frac{N_1}{N_2}\left(\frac{\delta \ln N_1}{\delta T}\right)_P = \frac{\Delta \bar{H}_2}{RT^2}$

whence
$$-\frac{1}{N_2}\left(\frac{\delta N_1}{\delta T}\right)_P = \frac{\Delta \bar{H}_2}{RT^2}$$

Now in dilute solutions, N_2 is approximately constant, and equal to unity, and $\Delta \bar{H}_2$ differs little from the heat of fusion of pure B. Inverting, we thus arrive at van't Hoff's equation,
$$-\frac{\delta T}{\delta N_1} = \frac{RT^2}{\Delta \bar{H}_2}$$

Pressure Variations.—Where the formation of solid solutions may be neglected, and dilute solutions only are dealt with, by a method of procedure similar to the above it may be shown that $\left(\frac{\delta \ln s}{\delta P}\right)_T = \frac{\Delta V}{RT}$ where s is the solubility of A in B and ΔV is the volume change for A on solution.

Corollary.—Corresponding to the van't Hoff equation, the relation $\left(\frac{\delta P}{\delta N_1}\right)_T = \frac{RT}{\Delta V_2}$ may be deduced where ΔV_2 is approximately equal to the molecular fusion volume change of the solvent.

Similar relations hold, of course, at the Boiling Point.

Solid-Solid Systems.

Such systems are important in metallurgy, but as thermodynamic equilibria are not often reached, it is doubtful whether the general equations,

$$\left(\frac{\delta \ln k_1}{\delta T}\right)_P = \frac{\Delta \overline{H}_1}{RT^2}, \text{ and } \left(\frac{\delta \ln k_1}{\delta P}\right)_T = -\frac{\Delta \overline{V}_1}{RT},$$

where $k_1 = \frac{(a_1)\text{solid}_I}{(a_1)\text{solid}_{II}}$ could often be applied. The latter formula is obviously of importance in any consideration of the equilibria involved in the cooling of the earth's crust, in which pressure variations have played an important rôle.

Summary and Conclusions.

The variation of distribution coefficient with temperature and pressure has been investigated. Following this a general method of investigation of the effect of temperature and pressure changes on any type of equilibrium has been developed in some detail. It is pointed out how the distribution coefficient and equilibrium constant follow identical laws with temperature and pressure variations. From this it is argued that "chemical" reactions differ from physical only in that the miscibility range in compounds is restricted and corresponds to definite stoichiometric proportions. Compound formation is merely a particular class of solution.

It will perhaps be objected that what applies for compounds must also apply for atoms. The existence of isotopes seems to indicate that elements, like solutions and compounds, are of variable composition, though the variations occur in fixed steps. Solubilities inside the atoms are governed by quantum steps; is this a general characteristic of solubility?

The author wishes to express his thanks to Professor C. E. Fawsitt, whose help and advice in connection with the presentation and publication of this paper have been of great value.

APPENDIX.

Confirmation and Application of Equation (4), viz.:—

$$\left(\frac{\delta \ln k}{\delta T}\right)_P = \frac{\Delta H}{RT^2}$$

System: Air ⟵ Bromine ⟶ Water. Sufficient data are available to test the equation on this system. Hantzsch and Vagt (Zeitsch für Phys. Chem. 1901, **38**, 705) have determined the distribution coefficient of bromine between air and water over the temperature range 0° to 60°. Their experimental figures are set out in the following table, together with our calculations of $\frac{d \log k}{d T}$ and of $\Delta H = 4.579\ T^2\left(\frac{d \log k}{d T}\right)$ Bromine is concentrated in the aqueous phase. Consequently, in writing Br_2 in air $\rightleftharpoons$ Br_2 in water, k (at 0°) = 63.15 etc.

Temp.	k	$\frac{d \log k}{d T}$	ΔH
0	63.15		
10	38.88	—0.0210	—7430
20	23.04	228	8660
30	15.31	177	7200
40	10.70	156	6780
50	7.84	135	6250
60	6.05	112	5520

Whence ΔH at 18° = —8,200 cals. The figures indicate that the experimental values of k are probably subject to considerable error, and therefore in estimating ΔH at 18° from the figures at 15° and 25° the error may be fairly considerable.

Berthelot and Ogier (Ann. de Chim. et de Phys., (5) 1884, **30**, 410) have measured the latent heat of vaporisation of bromine at 18°. They found that

$$Br_2\ (\text{liq.}) \rightleftharpoons Br_2\ (\text{vap.}), \quad \Delta H = 7{,}500 \text{ cals.}$$

From these two sources, both for 18°C., viz.:

$$Br_2 \text{ (vap.) in air} \rightleftharpoons Br_2 \text{ in water}, \quad \Delta H = -8{,}200$$
$$Br_2 \text{ (liq.)} \rightleftharpoons Br_2 \text{ (vap.)}, \quad \Delta H = 7{,}500$$

it follows that

$$* Br_2 \text{ (liq.)} \rightleftharpoons Br_2 \text{ in water}, \quad \Delta H = -700 \text{ cals.}$$

The ΔH value for the last equation has been determined experimentally by two experimenters, who give the following results at 18°.

Thomsen (Ber. 1873, **6**, 710) $\Delta H = -1080$ cals.
Pickering (J.C.S., 1888, **53**, 865) $\Delta H = (-1500$ cals.) ?

Pickering considered his own result doubtful, and placed greater weight on that of Thomsen. Without serious error we may therefore take ΔH to be —1,100 cals. for this action. This figure, which is an experimental one, agrees very well with that calculated above, viz., —700 cals. The calculated value involves use of the equation (4) and the close agreement may therefore be regarded as a confirmation of this equation.

Other Applications.—Variations of ΔH with temperature are generally not so great as those of the above table. Hantzsch and Vagt cite figures for several other systems. From these, two have been selected as illustrative of general classes of distribution.

System: $Fe(CNS)_3$ in ether $\rightleftharpoons Fe(CNS)_3$ in water.

Temp.	k	$\frac{d \log K}{d T}$	ΔH
0	0.532		
10	0.995	0.0272	9,600
20	1.814	261	9,900
30	3.303	260	10,600
35	4.32	234	9,800

* It is here assumed that $\Delta H = 0$ for the action Br_2 (vap.) in air $\rightleftharpoons Br_2$ (vap.) air free. This is probably very close to the truth.

Here ΔH varies little with temperature. It follows that the temperature coefficients of the heats of solution in the two solvents are practically identical.

System: $HgCl_2$ in toluene $\rightleftharpoons$ $HgCl_2$ in water.

Temp.	k	$\frac{d \log k}{d T}$	ΔH
0	12.35		
10	11.60	—0.0028	—990
20	11.40	—0.0007	—260
30	11.20	—0.0008	—320
50	11.25	+0.0001	+50 cals.

Here, the heat change in passing from one phase to the other is very small and the distribution coefficient changes but little with temperature.

Free Energy Changes for the above Systems.—Though the value of ΔH is so small for the last system considered, ΔF ($= -RT \ln k$) is rather greater. ΔF at 25° is set out for each of the above systems in the following table.

Change	k 25°	ΔH	ΔF
Br_2 in air $\rightleftharpoons$ Br_2 in water	19.17	—7,200	—1,750
$Fe(CNS)_3$ in ether $\rightleftharpoons$ $Fe(CNS)_3$ in water	2.60	10,600	—570
$HgCl_2$ in toluene $\rightleftharpoons$ $HgCl_2$ in water . .	11.30	— 320	—1,430

The difference between ΔH and ΔF represents the amount of heat which, if the change be conducted under reversible conditions, is absorbed from or emitted to the surroundings. In the first system this difference of 5,450 cals. represents the amount of heat lost to the surroundings even when the transference of one mol of Br_2 from air to water is carried out reversibly.

THE DEVELOPMENT OF THE INFLORESCENCE OF *AVENA SATIVA*, L.*

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(Communicated by Professor R. D. Watt.)

(With seven text-figures.)

(*Read before the Royal Society of New South Wales, Aug. 7, 1929.*)

Introduction.

Very little investigational work of a detailed microscopic nature has been done with oats, the greater importance of wheat having eclipsed the other cereals, with perhaps the exception of barley, which, owing to its malting qualities, has received a great deal of study, especially in connection with the grain. Cannon (2) made a very complete study of the development of the flower and embryo of *Avena fatua*, but paid no special attention to the development of the inflorescence as a whole.

While a detailed description of the mature panicle of oats is deemed unnecessary, for the sake of completeness, some reference must be made to those special features which have a definite morphological bearing on the developmental work that follows.

The main axis or rachis of the inflorescence is a continuation of the stem of the plant, and is normally straight or only slightly undulating. Each half whorl of branches arises from a node in the rachis similar to the nodes of

* The morphological work included in this paper is a small section of a dissertation (Callaghan (1)) presented at Oxford for the degree of Doctor of Philosophy, and as yet unpublished.

the lower unspecialised portions of the culm. The branching of the main axis is racemose, that of the side branches, cymose.

A scheme of branching is indicated in Figure (1), which according to Zade (11) was propounded by Fernekess (8). From this and from figures (6 and 7) it will be seen that

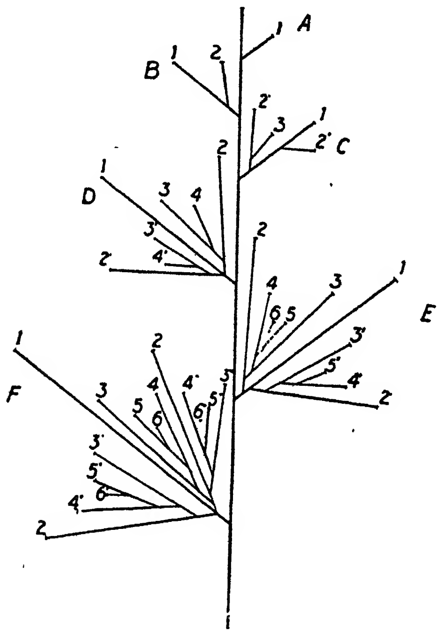

Fig. 1.

Scheme of the panicle branching. The primary branch of each node is marked 1, whilst secondary branches and branches of higher order are marked 2, 3, 4, etc., respectively. (After Fernekess.)

only the one primary branch arises from each node, 1; this gives rise to two lateral branches, 2, each of which gives rise to branches of higher order, 3, 4, etc. The branching is more profuse at the base of the panicle, diminishing gradually in degree towards its apex; similarly

the branches decrease in length from those of the lowest node, which are the longest, to those of higher origin on the rachis.

The spikelet represents the unit of inflorescence and consists of a short axis, the rachilla, bearing one to four flowers, one, two, or three of which may develop, the upper flowers, or flower, remaining rudimentary and imperfect.

In sharp contrast to one another are the equilateral, or spreading panicle, and the unilateral, or one-sided panicle. The branches of the latter remain almost erect and closely adpressed to the rachis, whilst twisted growth completes the apparent one-sidedness.

Attention is drawn to the nature of the branching from the lowest node of the unilateral panicle. The branching from the first node of the rachis in this case is morphologically the same as in the equilateral panicle, but the secondary branching is delayed somewhat, so that variously long intervals occur between the node, or point of initial branching, and the actual point of isolation of the secondary branches, and in some instances a false node is the result.

Denaiffe and Sirodot (4, loc. cit. p. 40) have described and figured abnormal nodes of unilateral panicles. Etheridge (5) and Marquand (10) regard the false node phenomenon as varietal, and both use it in their classifications for purposes of distinguishing between certain varieties of *Avena sativa orientalis.*

Figure (2) shows the nature of the branching from the first node of various forms. A represents that of an equilateral panicle showing the branches isolated at a level corresponding to that of the "collar". B is of the unilateral type, and in this there is a short interval between the level of the "collar" and the actual point of isolation

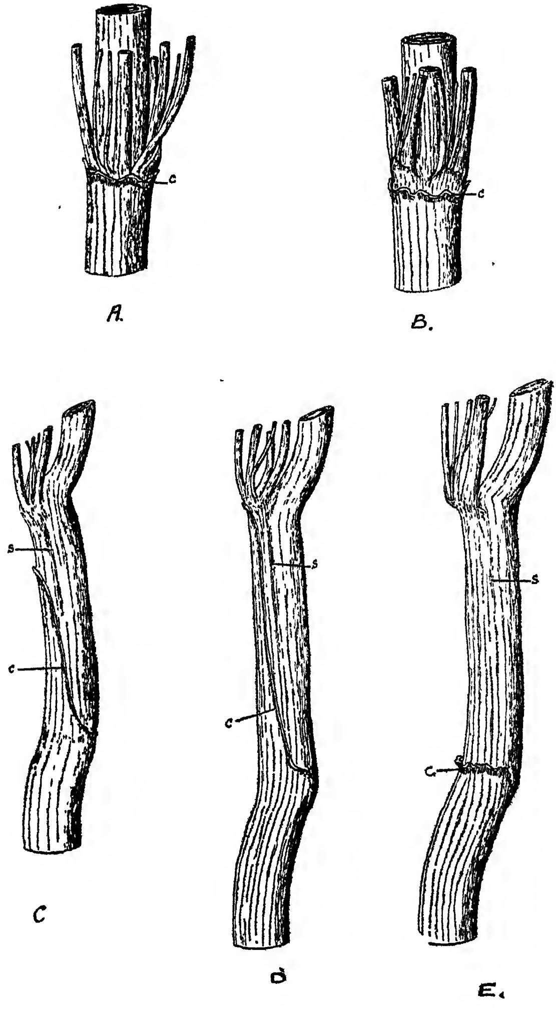

Fig. 2.

Showing variations in the manner of branching from the lowest node of the rachis. A, that of an equilateral panicle; B, C, D, and E, various forms of the unilateral Panicle, c, "collar" or vestigal bract; s, suture. $\times 3$.

of the branches. In the abnormal unilateral forms, the condition shown in B is extenuated still further, and the branches are consolidated for some distance above the actual node, not only with themselves, but together with the rachis. The false node thus formed is illustrated in C, D, and E of figure (2). The faint suture there shown is usually quite distinct along the rachis, between the false node and the true node below. Intermediate expressions are commonly met with in the same variety.

The nature of the "collar" is similarly very variable. In D the latter extends from the level of the node to the point of isolation of the branches; in C it is only partially extended in this way; while in E, it is not extended but remains near the node, as in the normal panicle. This "collar" is present in all oat inflorescences, and in the equilateral panicles of two recently evolved Australian varieties, (Boppy and Kiah), it has been observed as a distinct bract extended into a leaf-like flange.

Developmental Phases.

Several very important changes take place in the development of the plant between the time of the unfolding of the first foliage leaf and that of the fifth. Briefly these may be stated as, (1) the initiation of adventitious root development, (2) the beginning of internode elongation, resulting in the so-called "shooting" of the stems, (3) the establishment of tiller buds in the axils of the coleoptile and of the first three or four leaves, and (4) differentiation of the inflorescence primordium at the apex of the primary shoot. The first three of these important changes develop simultaneously, but the rudiments of the inflorescence do not appear until the tillering process is under way, and after its origination no further leaf rudiments appear, and all the tillering buds that are to be formed as direct offshoots of the main axis are already differentiated.

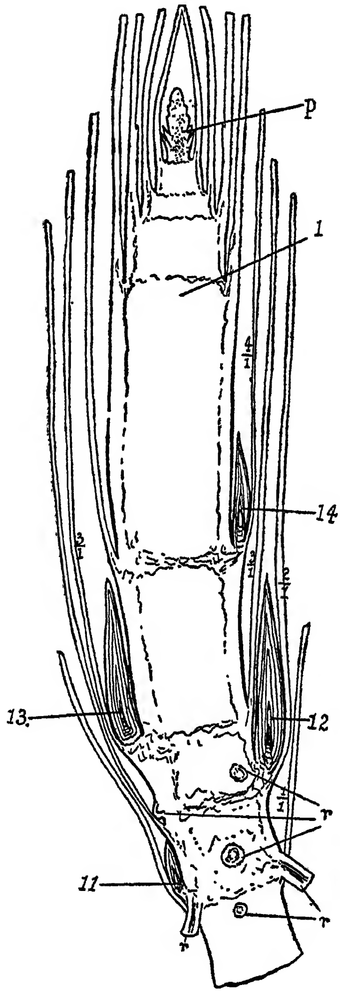

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Fig. 3.

Diagram to show the state of development of the young plant at the close of the fourth leaf-stage. The main axis is represented by 1 and successive leaves of that axis, commencing with the coleoptile, as $\frac{1}{1}$, $\frac{2}{1}$ etc. and the shoots as 11, 12 etc. *r*, roots, and *p*, rudiments of the inflorescence. $\times$ 12.

It is evident, therefore, that the rudiments of the mature plant, excepting accidents,* are established by about the time of the unfolding of the fifth leaf, those of the main axis by the commencement of the fourth leaf-stage, and

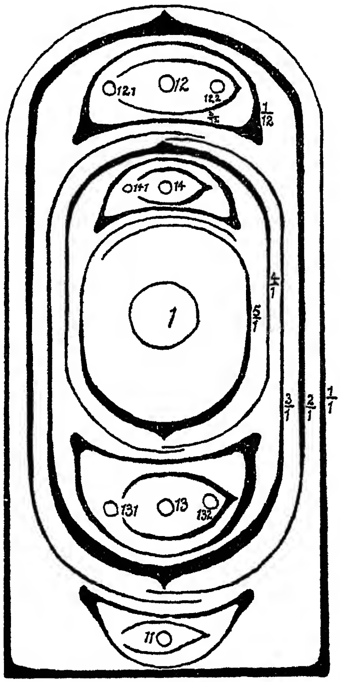

Fig. 4.

To show the relation and orientation of the leaves and axes of the young plant. Indications the same as in figure 3.

subsequent growth is concerned with the development of the inflorescences and the elongation of the internodes of both main and lateral axes, the latter synchronizing for the most part with the unfolding of the successive leaves of the plant.

* Accidents to the plant such as fungus or insect attack, or destruction by grazing animals.

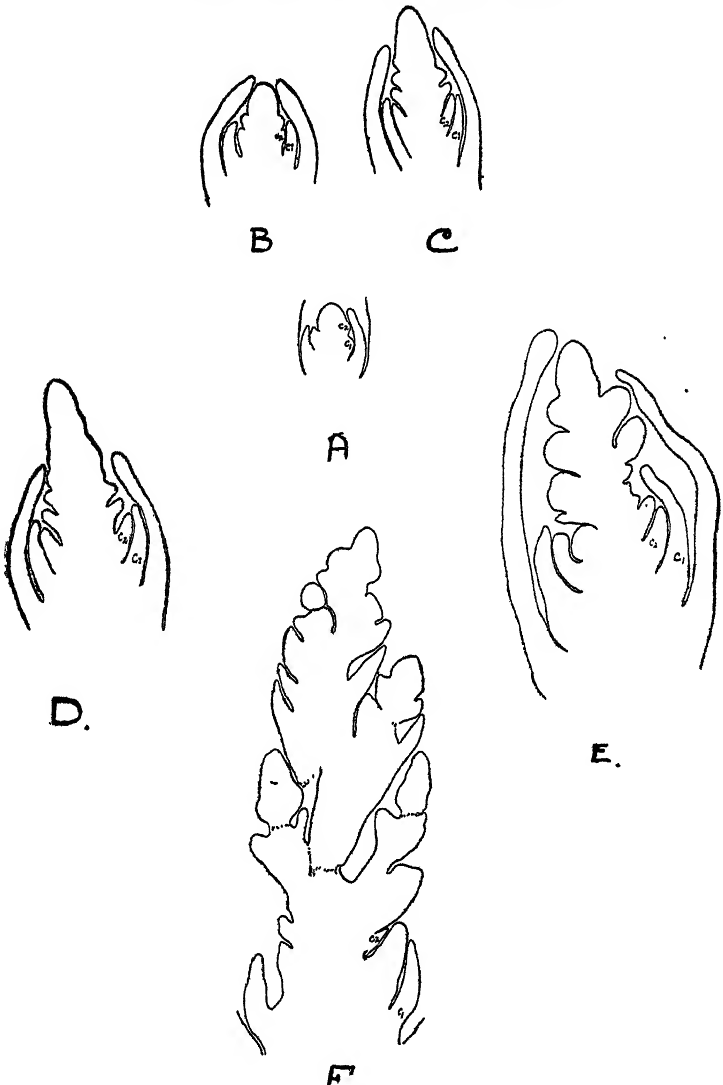

Fig. 5.
Median longitudinal sections of the developing inflorescence. A, at the close of third leaf stage; B. fourth leaf stage; C, fifth leaf stage; D and E, sixth leaf stage, and F, close of sixth leaf stage. c_1 and c_2, collar or vertigial bract of lowest and second lowest node of the rachis. ×83.

The state of development of the young plant at the close of the fourth leaf-stage, when the folded tip of the fifth leaf is just peeping, is represented diagrammatically in figure 3, and the relation and orientation of the axes and leaves is shown in figure 4.

Development of the Inflorescence.

The foregoing remarks make it clear that the development of the inflorescence commences very early in the life of the plant after all the leaf rudiments have formed. The first signs of development are evident at the close of the third leaf-stage (see figure 5, A).

Two low, primary ridges of tissue, similar in origin and continuing the alternate arrangement of the foliage leaves, make their appearance around the periphery, and at the base of the merismatic apex (figure 5, c_1 and c_2 of all drawings). These flanges mark the positions of the first and second nodes of the rachis, and they persist as vestigial structures in the mature inflorescence, referred to previously as the "collars".

The meristem above these nodes then elongates and at the same time bulges of tissue originate throughout its length (see figure 5, E), each extending partially around the primordium. These subsequently develop into the branches of the higher nodes. Thus in the eighth drawing of figure 6, the initial of branch *a*, is accompanied by the alternate branch *b* at a lower level on the rachis, represented in sections *7* and *6*; and similarly down the rachis (*Ax*) the alternate branches *d, e,* and *f* originate in that sequence, as the remaining sections of figure 6 show.

For some time the chief development of the inflorescence is concerned with the higher-placed branches, followed later by an elongation of the internode between the lower nodes, and branching from the axils of the vestigial bracts.

Successive stages in the development are shown in the drawing of figure 5, representing median longitudinal sections of the developing inflorescence. The leaf-stage is recorded in each case by way of correlating vegetative development with that of the inflorescence. By reference to figure 5, it is evident that until the sixth leaf of the

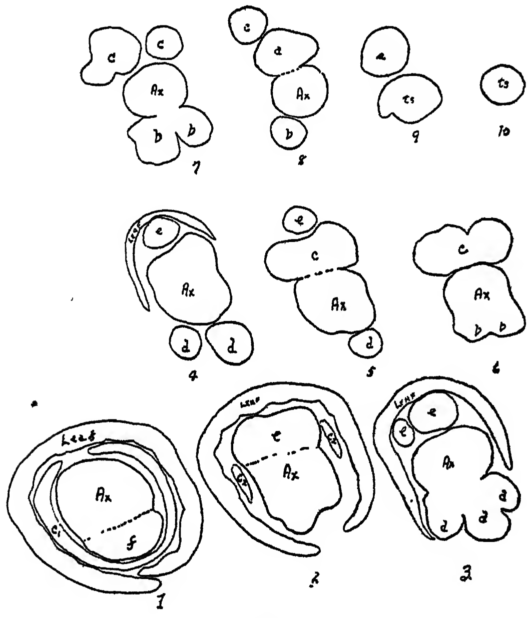

Fig. 6.

Series of transverse sections through a developing inflorescence, of the same stage as E of figure 4. The main axis is represented as Ax, and the successive series of branches as *a*, *b*, *c*, *d*, *e* and *f*, respectively. *ts* represents the terminal spikelet. × 74.

axis has unfolded no very marked advance is made in inflorescence growth. During the sixth leaf-stage, however, the full complement of branch primordia are established, the last of which to appear being that from the axis of the lower flange or vestigial bract. This phase may be followed by reference to the transverse sections of figure 6,

where the lowest branch primordium is represented as a bulge of tissue, *f*, in the axis of the vestigial bract c_1; whilst in alternate arrangement with the latter, the next lowest branch *e*, in the axis of a second vestigial bract c_2, has already reached the stage of rebranching, as the two portions marked *e* in the third drawing of the same figure indicate. Further progress in the growth and rebranching of the lower branches *f* and *e* are traced in the successive drawings of figure 7. These drawings are transverse representatives of the median longitudinal section shown in figure 5, F.

Each branch primordium that arises undergoes rapid elongation accompanied by a similar growth in length of the rachis between them. Spikelet primordia develop at the apex of each branch, whilst others arise sympodially along the axis of the branches. The spikelet terminating the rachis is the first of the panicle to develop. Spikelet development, however, does not come within the province of this paper. Figure 6 shows a series of transverse sections through a developing inflorescence at the same stage as that depicted longitudinally in figure 5, E, and in this, marked *ts*, the first evidence of spikelet formation at the apex of the rachis is shown. Further, it will be seen that although the terminal spikelet is at this advanced state of development, branching has only just begun at the lowest node. This figure also shows the regular alternate manner of branching throughout the inflorescence.

Significant Relationships.

The early stages above described, during which the foundations of the plants' yielding capabilities are being laid down in the form of inflorescence and spikelet primordia, mark the first, and probably the most important, critical period of its existence. It is during this period

that the plant decides, as it were, on the production possible, from the cultural material available.

The phenomenon described by practical workers with oats as "bolting", results in very poor panicle develop-

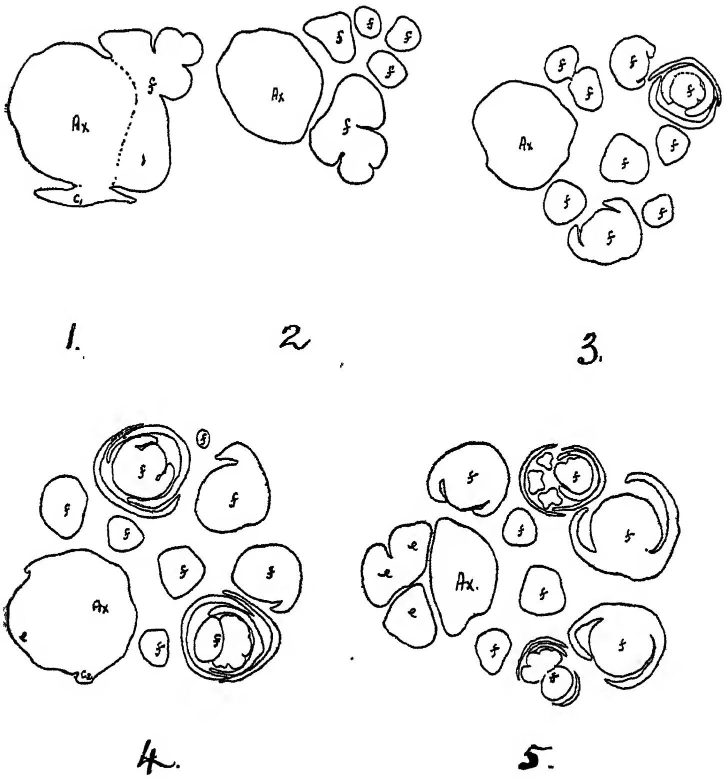

Fig. 7.
Series of transverse sections through the two lowest nodes of the rachis of an inflorescence at the same stage of development as F in figure 4. The indications are the same as those in figure 6. Note the spikelets of *f* in various stages of development. × 78.

ment. Two papers by Elliott (6, 7) deal with the specific problem of Oat Blast and Sterility in Oats; in these the fact is established that these lesions are non-pathogenic, and that they are most probably of a physiological nature.

"Bolting" differs to some extent from Oat Blast described by Elliott (6, 7), in that many sterile spikelets may appear on otherwise fully developed panicles; nevertheless, the conditions seem to be related in certain cases. Oat Blast, as Elliott (6, 7) points out, is probably controlled by weather conditions at the time of panicle exsertion. This latter period is without doubt the second crucial stage in the life of the plant, and cultural conditions then materially affect the ultimate yield of each inflorescence.

In plants that have "bolted" the two lower nodes, or even more, fail to develop branches, and the panicle may only produce five to ten spikelets, or as occasionally happens, only the terminal spikelet. The conditions of culture as controlled by soil and weather, and the time of sowing are intimately connected with the development of the panicle. If the equilibrium of growth is interfered with at the time of development of inflorescence primordia, shooting of the culms may progress rapidly following on more favourable conditions, allowing only time for the establishment of the upper branches and spikelets of the panicle. In all cases of poorly developed panicles, however, the two vestigial bracts demarking the lower nodes of the inflorescence are clearly defined; this is to be expected from the order of development of the inflorescence parts.

It is suggested that the recently evolved science of photoperiodicity may have a significant bearing on the above problem, for late sowings appear to result in a higher percentage of bolters, or panicles bearing sterile spikelets. The length of day may determine the phase of rapid growth that results in reproduction at a time when the plant is physiologically unprepared.

From figure 3, it will be seen that prior to the elongation of the internodes, the inflorescence and four or five of the higher internodes are crowded together at the apex of each

stem. It is at this stage (i.e., the fourth or fifth leaf-stage) according to Cunliffe, Fryer and Gibson (3) that the plant is most liable to Frit Fly attack. From the foregoing developmental description several reasons for the noticeably high mortality of plants at this specific stage present themselves.

(1) The three or four highest nodes of the plant are crowded together and surmounted by the developing inflorescence, as yet very small, thus the larva passing down between the folded leaves and leaf-sheaths at this stage is very soon brought into contact with the most actively-growing regions of the plant, and is more liable to destroy the shoot while the inflorescence is so small and accessible.

(2) The concentration of sugars in the region of the developing inflorescence and the unelongated internodes is probably at its highest during the life of the plant at this period prior to active elongation of the stems and panicle formation.

(3) As the larva is small, a certain amount of leverage gained from the tightly folded young leaves and leaf-sheaths at this stage may facilitate its entry, and at the same time direct it to the growing apex of the plant.

The first of these points must, it seems, have a significant influence upon the mortality of the plants. Once the internodes commence to elongate, the nodes become more widely separated and the inflorescence is carried higher, thus the chance of the plant surviving an attack should increase accordingly. Further, there is a decided strengthening and thickening of the stem and leaf-sheath tissues after the initial elongation of each internode.

1. Frit Fly (*Oscinella frit*) fortunately is unknown in Australia, but in Great Britain and Europe generally, it is by far the most troublesome and destructive pest attacking oats.

From observations and measurements of the internodes of two widely different varieties up to the fifth-leaf stage, little difference in the rate of internode growth was observed, though the varieties showed constant differences in internode length. Whether there is a varietal difference between the rate of internode growth after the fifth leaf-stage, which is the critical period from the point of view of Frit Fly attack, remains undecided, but it is a point worthy of careful study. Differences in such rate of elongation may have some bearing upon the higher susceptibility of some varieties over others.

The most likely reason, however, for the extreme susceptibility of the plant at the fourth and fifth leaf-stages, is that concerned with the nature of the cell sap at that period. Should the concentration of sugars be the controlling factor in attack, it becomes a difficult and well-nigh impossible task to find an index to explain the comparative resistance of certain varieties.

Recently Finnell (9) published data indicating different results from the grazing of wheat at various stages in its early growth. Oats now take their place as a grazing proposition in Australia and undoubtedly the correct time to graze is of basic importance. It is suggested that the latter problem is closely concerned with the development of the inflorescence.

From Finnell's (9) work with wheat it seems that his remarks may be equally true for oats, i.e., "that while sound plants are reduced in total production by late grazing, their response in numbers of replacement shoots formed is in respect to the degree of partial or entire replacement required."

Late grazing, and the consequent complete destruction of already differentiated panicles, necessitating complete

replacement by the growth of secondary tillers, appears to have a doubtful advantage over an early grazing, whereby a high percentage of initiated panicles may escape destruction, and only partial replacement be necessitated.

Summary.

1. A relative description of the mature inflorescence is given, special attention being paid to the false node of some unilateral panicles.

2. Growth phases synchronising with inflorescence development are briefly related.

3. The development of the inflorescence, as studied in the variety Abundance, of the species *Avena sativa*, L., is described and figured.

4. The following problems appear to be significantly related to the development of the inflorescence:—

(a) The phenomenon known as "bolting" in oats.

(b) Frit Fly attack.

(c) The correct time to graze a young crop of oats.

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THE OCCURRENCE OF A NUMBER OF VARIETIES OF EUCALYPTUS DIVES AS DETERMINED BY CHEMICAL ANALYSES OF THE ESSENTIAL OILS.

PART III.

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(Read before the Royal Society of New South Wales, 4th Sept., 1929.)

In our Part I. Paper on this subject (this Journal, Vol. LXI., page 57), reference was made to the so called Victorian type of *Eucalyptus dives*, described therein as E. dives var. "A."

Our first-hand knowledge of this form of *Eucalyptus dives* was confined, apart from the examination of essential oils submitted for report, to practically one part of New South Wales, viz.: Spring-grove, near Braidwood. The opportunity was, therefore, availed of in the course of a hurried visit to Victoria during the month of May this year, to inspect the principal areas of Eucalyptus dives occurring in that State, mainly in the North-East corner.

Through the courtesy of W. K. Burnside, Esq., who arranged an itinerary, one of us (A.R.P.), was enabled to visit expeditiously practically all the areas of country under commercial exploitation, and thus the very necessary first-hand knowledge of these most interesting and important fields was acquired. Samples of leaves and terminal branchlets from various individual trees were

secured, and in every instance the results of the examination of the essential oils obtained therefrom confirmed the field observations.

Areas of *Eucalyptus dives* at the following places were critically examined, viz.: Tallangatta and Craven Hill in the Tallangatta Valley, Whitfield, and Blackwood, near Trentham. The trees occurring in the Tallangatta Valley and at Whitfield were found to consist essentially of the Type with a sprinkling of trees of variety "A." The soil was good and the country generally was of a superior and richer type (more suitable for agricultural purposes), than the poor granite and sandstone country in New South Wales.

Although a comparatively limited area of country could be traversed in the time available, yet quite a large number of trees distributed over various working fields were examined. Particular attention was given to the so called "sucker" leaves, i.e., the new growth from the stumps of old trees which had previously been cut for distillation purposes. Only in one instance was an apparent intermediate form detected (see this Journal, Vol. LXI., page 57), as will be observed from results in Table "A." Most of the trees examined, especially in a large area such as that of Whitfield, were found to be *Eucalyptus dives*, Type, with an admixture of var. "A."

The field observations, confirmed by laboratory examinations of the essential oils (see Table "A"), furnishes the reason for the lower piperitone content of *Eucalyptus dives* oil obtained from this important field, i.e., admixture of var. "A" with the Type.

On the other hand, the areas of *Eucalyptus dives* at Blackwood near Trentham proved extremely interesting, not only on account of their vastness, but for the fact that they consisted almost entirely of var. "A."

TABLE "A." EUCALYPTUS DIVES AND ITS VARIETIES FROM VICTORIA.

Date.	Locality.	Yield of Oil.	$d\frac{15}{15}$	α^{20}_{D}	n^{20}_{D}	Solubility in 70% Alcohol.	Piperitone content	Remarks.
15/5/1929	Tallangatta Valley, N.E., Victoria.	3.3%	0.9035	$-52.10°$	1.4816	1.2 vols.	54%	Adult leaves from H. Rousseau's property. Altitude, 1175 – 1200ft.
do.	do.	2.7%	0·9026	$-71.7°$	1.4791	7.0 vols.	49%	Ditto. Average of "sucker" growth
do.	Craven Hill Tallangatta Valley.	2.4%	0.9017	$-64.65°$	1·4816	1.6 vols.	49%	Sucker growth from H. N. Supple's property (green leaf.) Altitude, 1200ft.
do.	do.	3.5%	0.9001	$-69.7°$	1·4793	1.6 vols.	49%	Ditto, ditto (glaucous leaf.)
21/5/1929	Whitfield.	3.85%	0.9019	$-58.2°$	1.4811	1.6 vols.	47%	Sample of adult leaves taken from stack ready for commercial distillation. Altitude 2000ft. Small quantity of var. "A" detected.
do.	do. Sample "A"	1.17%	0.8995	$-58.6°$	1.4828	8.0 vols.	30%	Selected as doubtful } Sucker leaves about 2 years old. Altitude 1400 – 1500 ft.
do.	do. "B"	2.1%	0.8761	$-53.75°$	1.4792	insoluble 10 vols.	5%	do. as var. "A"
do.	do. "C"	5.2%	0.9117	$-56.75°$	1·4768	1.4 vols.	40%	do. as type
do.	Blackwood (1)	2.6%	0.8879	$-32.35°$	1.4791	insoluble 10 vols.	2%	Average material of variety "A." Altitude, 1825 feet.
do.	do. (2)	4.1%	0.8796	$-55.5°$	1.4783	10 vols.	2%	do. narrow leaf form.

The oil from Blackwood, sample No. 1, had Ester No. 7.8 Ester No after acetylation 76.49.
ditto sample No. 2, had Ester No. 6.4 ditto 57.64.

The trees were typical of *E. dives,* both when examined in the field, and when judged by morphological characters. Specimens submitted to Mr. E. Cheel, Curator of the National Herbarium, Sydney, were duly determined as such.

In the Part II. contribution (this Journal, Vol. LXII. (1928), pp. 72-78), we dealt exclusively with *E. dives* var. "C," and further investigations made since that date have merely confirmed the data contributed therein.

However, one particular examination is worthy of record, being typical of many, as it affords confirmatory evidence of the value of examining leaf material under certain conditions by olfactory means without the expenditure of the time and labour involved in subjecting it to steam distillation and subsequent chemical examination of the essential oil.

A correspondent furnished a bag of leaves and terminal branchlets of Eucalyptus leaves from the Tumbarumba District of New South Wales (this Journal, Vol. LXII. (1928), pp. 72-78), for report as to their suitability for the commercial production of Eucalyptus oil. By crushing the leaves in the hand and observing the odour, it was possible within a few minutes to furnish a reply to the effect that the oil would be of negligible commercial value.

The leaves could be sorted into those of *Eucalyptus dives,* Type, *E. dives,* var. "A," and *E. dives,* var. "B," and consequently the oil obtained from such a mixture of leaves would be of no value either as a source of piperitone or for sale as a pharmaceutical oil. However, in order to provide convincing evidence for our correspondent, the mixed leaves were subjected to steam distillation, when an essential oil in good yield (3.2%) was obtained, possessing the following chemical and physical constants, viz.:—

Specific Gravity	0.9044
Optical Rotation	—26.6°
Refractive Index	1.4710
Piperitone content	15%
Cineol	10-15%
Phellandrene	present in abundance.

TABLE "B," EUCALYPTUS DIVES FROM VICTORIA.

Date	Locality	Yield of Oil.	$d\frac{15}{15}$	α^{20}_{D}	n^{20}_{D}	Solubility in 70% Alcohol. (by weight).	Piperitone content.
27/4/1925	H. N. Supple, Craven Hill.	2.9%	0.8866	−68.7°	1.4783	10 vols.	36%
30/7/1925	H. W. Smith, Koetong.	3.4%	0.9062	−57.3°	1.4810	1.4 vols.	53%
29/9/1925	D. W. Kelly, Koetong.	4.0%	0 9008	−62.0°	1.4799	1.6 vols.	48%
3/11/1925	H. Short, Corryong.	4.0%	0.8982	−59.5°	1.4802	5.5 vols.	46%

As this paper deals almost exclusively with *Eucalyptus dives* from the State of Victoria, a series of analyses of essential oils from leaves obtained from that State during the past 5 years and not hitherto recorded, have been included in Table "B." Although there is still some evidence of the occurrence of Forms of *Eucalyptus dives* intermediate between the Type and var. "A," as recorded in our Part I. contribution, we are of the opinion that in the great majority of instances where the piperitone content of the essential oil fluctuates between 26 and 36% it is invariably due to admixture of leaves of the Type and var. "A," such as was observed in the Whitfield District of Victoria.

If confirmation regarding the stability of each of the varieties described were needed, it is only necessary to state that, over the areas of country traversed, it has been

observed that large areas of each variety exist, and in any one locality one particular variety appears to predominate over the other varieties: thus, in the Braidwood district of New South Wales, the normal Type prevails, being associated with but small quantities of var. "A"; near Goulburn, New South Wales, are found both the Type and var. "B"; the predominating species in the Tumbarumba district, New South Wales, is var. "C," with very little of the Type; and in Victoria, very large areas of var. "A" are growing in conjunction with the Type species. It is thus apparent that all forms of *E. dives* are well established as separate varieties, according to the chemical composition of the respective oils.

In conclusion, we desire to express thanks to W. K. Burnside, Esq. (Messrs. W. K. Burnside, Pty. Ltd., Melbourne), for his practical assistance in not only accompanying one of us to the Victorian areas of *Eucalyptus dives*, but also in providing the very necessary means of rapid transit.

THE TESTING OF LEAD AZIDE DETONATORS.

By J. A. CRESSWICK, A.A.C.I., F.C.S.
and
S. W. E. PARSONS, A.A.C.I., A.S.T.C. (Chem.).

(Read before the Royal Society of New South Wales, 2nd Oct., 1929.)

The term "detonator" is defined by the "Explosives Act, 1905," as a "capsule" or "case," which is of such strength and construction, and contains an explosive of the Fulminate-explosive class in such quantity that the explosion of one capsule or case will communicate the explosion to other like capsules or cases.

In appearance it consists of a cylindrical shell of either copper or aluminium closed at one end and containing a charge of explosive. The mixture almost universally used until quite recently was Mercury Fulminate and Potassium Chlorate (80:20) as the initiating agent, the quantity used determining the number assigned as a guide to strength.

Thus No.	5	detonator	contained	0.8	grms.	mixture.
„	6	„	„	1.0	„	„
„	7	„	„	1.5	„	„
„	8	„	„	2.0	„	„

For some time manufacturers in various parts of the world have sought a new substance or mixture which would replace the Mercury Fulminate-Potassium Chlorate mixture, and not possess the same objectionable features, i.e., (1) liability to moisture absorption, and (2) sensitiveness to shock in handling. Amongst those involved was a mixture containing Tetryl (tetra nitro methyl aniline) with Lead Azide priming. It was claimed for this mixture that it did not possess the objections referred to. Moisture absorption is practically negligible, and field use has shown

a superiority over the older type in the question of sensitiveness to shock in handling.

The Tetryl-Lead Azide mixture was filled into aluminium tubes, and the manufacturers forwarded a small parcel to this State, early in 1927. We might here state that aluminium tubes were used instead of copper, since it was found that with copper objectionable compounds were formed. Samples selected for examination were submitted to the Sand Test, evolved by C. G. Storm and W. C. Cope at the Bureau of Mines Laboratory Testing Station, Pittsburg, U.S.A. This test consists essentially in weighing the amount of sand which passes through a 100 mesh sieve, after having been crushed by the detonator in a suitable bomb. The detonators (termed No. 6) were found to crush an amount of sand similar to that crushed by a No. 6 Fulminate type detonator, and were authorised for manufacture in or importation into this State.

Later shipments received, however, gave results considerably lower than previously obtained, indicating that the quantity of composition had been reduced or had deteriorated in quality. The weights of composition compared were as follows:—

Original authorisation	0.852 grms.
Later shipments	0.586 grms.

The manufacturers claimed that the Sand Test results obtained were not a true indication of the detonating efficiency, and that the later shipments, notwithstanding the decrease in the amount of composition used, were as efficient as the Mercury Fulminate-Potassium Chlorate type of the same number.

An investigation was accordingly carried out by the Explosives Department to determine whether or not such was a fact.

In carrying out the investigation referred to above, it was decided to utilise the ballistic pendulum, so that a direct reading might be obtained of each shot fired. As a preliminary, charges of 10 grams, each of standard non-gelatinous powders, were fired, using alternatively the aluminium and copper type detonators. Results obtained, expressed in degrees of deflection, are summarised below:

Explosives Used.	Copper Detonator.	Aluminium Detonator.
40% Lig. Dyn.	19.0	20.5
Stonobel	16.6	18.2
Quarry Monobel	20.4	22

Further experiments were then conducted, using the same explosives and desensitising them by means of liquid paraffin, to determine the point at which one type detonator would fire the charge whilst the other type failed.

Various percentage additions of liquid paraffin were made. Results of experiments are expressed below:—

Explosives Used.	Copper. Detonator.	Aluminium Detonator.
40% Lig. Dyn.—		
5% mixture	22.3	—
10% mixture	18.8	22.3
15% mixture	failure	21.7
Stonobel—		
10%	17.7	20.3
12½%	20.0	20.55
15%	part failure { 12, 10.6, 9.5	18.4
Quarry Monobel—		
5%	—	exceeds 24
10%	21.5	—
15%	part failure 12	23.5

After a lapse of two months, the above mixtures were again tested, using aluminium detonators, and it was found that in each case complete detonation of the charge resulted, with development of power, as indicated by the degree deflection, the same as when previously tested and freshly made.

These results conclusively prove that the aluminium (Lead Azide) detonators, as at present imported, are slightly more efficient as initiating agents than the older copper (Mercury Fulminate) type of the same number.

The desensitised non-gelatinous explosive test appears to offer considerable advantages over the Esop test, which uses picric acid desensitised with olive oil, as the quantity additions are larger and the desensitised mixture can be used over a period of at least one month and still give reliable results, enabling a much greater ease of manipulation and reliability for comparative purposes. However, the Sand Test shows reliability and consistency in comparison with the weights of composition, so that it will be still maintained as the routine test for comparison of shipments and checking deterioration from the determined standard. It is, however, in the comparison of the new types of detonators that the desensitised Nitro-Glycerine test gives more reliable results than tests at our disposal prior to the investigation.

In conclusion, we would express our appreciation of the Superintendent's permission to communicate the contents of this paper to this Society.

EXHIBITS.

(1) The Pittsburg Sand Tester and Accessories.

(2) Samples of various detonators with composition removed.

THE ACTION OF ACIDS ON DIAZOAMINOBENZENE

By J. C. Earl, D.Sc., Ph.D.

(Read before the Royal Society of New South Wales, 2nd Oct., 1929.)

From time to time the existence of modifications of diazoaminobenzene having lower melting points than the normal product has been recorded (Fischer, Ber., 1884, *17*, 642; Walther, J. Pr. Chem., 1897 ii, *55*, 548; Orloff, J., Russ. Phys. Chem. Soc., 1906, *38*, 587). Such a product was encountered during a study of the reaction between aniline and pinene nitrosochloride (Earl and Kenner, J., Chem. Soc., 1927, 1269), and led to the present investigation.

The conditions under which the reaction between pinene nitrosochloride and aniline gives rise to diazoaminobenzene are such that the presence of small quantities of hydrochloric acid is not precluded. In the total absence of hydrochloric acid, although not of acetic acid, the reaction takes a different course with the formation of pinene nitroanilide. The clue to the low-melting point of the diazoaminobenzene was sought, therefore, in its behaviour with very small quantities of hydrochloric acid.

Treatment of carefully purified diazoaminobenzene in cold alcoholic solution with very small quantities of hydrochloric acid certainly led to low-melting products. from which pure diazoaminobenzene was not readily obtained by fractional crystallisation. This excludes the possibility of the low melting point being due to the presence of aminoazobenzene (cf. Rosenhauer and Unger, Ber., 1928,

61B, 392), since diazoaminobenzene is crystallised readily in a pure condition from mixtures in which only it and aminoazobenzene are present. The possession of low melting point is accompanied by the property of producing a deep-red colour with alcoholic alkalies, a property which has long been observed as a common one of unpurified preparations of diazoamino compounds (cf. Hantzsch and Perkin, Ber., 1897, *30*, 1399), but for which no explanation has been assigned.

Previous work on the action of acids on diazoaminobenzene has definitely proved the following:—

(1) With moderately concentrated acids, hydrolysis into a diazonium salt and a salt of aniline takes place; on heating secondary reactions consequent on the break-down of the diazonium salt are observed.

(2) With dilute acids, there is more or less complete conversion into aminoazobenzene, no intermediate products having been detected with certainty.

The experiments here described amplify this information by showing that the first effect of acids upon diazoaminobenzene is to produce a substance (A), which apparently forms coloured salts with alkalies in alcoholic solution. If the action is prolonged, under the same conditions of temperature and acid concentration as those required to produce A, the latter disappears and, as far as can be judged, a practically quantitative conversion into aminoazobenzene takes place. It may be taken, therefore, that A represents an intermediate stage in the diazoamino-aminoazo transformation. In these experiments, the concentration of acid was very low; a 0.1 to 0.2 per cent. alcoholic solution of hydrochloric acid was employed. With more concentrated acid, a partial hydrolysis in the sense of (1) is

observed, and under extreme conditions the formation of aminoazobenzene can be almost entirely avoided.

If it were possible to isolate A in a pure condition, the matter of determining its relationship to diazoaminobenzene on the one hand, and aminoazobenzene on the other, would be greatly simplified. However, in spite of repeated attempts, a satisfactory purification has not been accomplished. Partly for this reason, and partly on account of the very large mass of conflicting evidence which is available on the whole subject of the hydrolysis, constitution and rearrangement of diazoamino compounds, discussion of the more theoretical aspect of the question is reserved for a later communication.

The action of small quantities of acids upon diazoaminobenzene being so pronounced, it is obviously desirable to prepare it, as far as possible, under non-acid conditions. In the course of the present investigation, a method was devised which yielded directly almost pure diazoaminobenzene of a golden yellow colour. One or two crystallisations were necessary to bring it to a state of purity. The procedure is described in the experimental part of this paper.

Experimental.

Conversion of pure Diazoaminobenzene into a product of low melting point.

Purified diazoaminobenzene (2.5 grams) which yielded only a faint red colour with alcoholic potash was dissolved in spirit (50 cc.) and cooled to 17° C. A solution of hydrochloric acid (0.2 cc. concentrated acid) in spirit (20 cc.) was then added, and the mixture allowed to stand at room temperature (14° C.) for ten minutes, after which it was poured into distilled water (20 cc.) and stirred thoroughly. After filtration and drying in a vacuum desiccator over sulphuric acid, the product (2.05

grams) melted at 91-92° C., and retained this melting point after storage for several weeks. Found (micro) N, 21.6 per cent. The product gave an intense red colour with alcoholic alkalies.

Quantitative estimation of "diazo" nitrogen.

A weighed quantity of the product (0.2 to 0.3 grams) was treated with aqueous hydrochloric acid (10 cc.; 1 vol. concentrated acid diluted with 3 vols. water), in an apparatus from which all air had been expelled by carbon dioxide. The reaction was carried out at 65 to 70° C., and the evolved gas driven into a nitrometer filled with potash (50 per cent. by weight).

Material.	Per cent. "diazo" nitrogen found.
Pure diazoaminobenzene	14.3
Acid treated diazoaminobenzene, m.p. 91-92° C.	13.6
Recrystallised, m.p. 83° C.	13.8

The calculated yield of nitrogen from diazoaminobenzene is 14.2 per cent.

Attempts to estimate the amount of aminoazobenzene formed in these experiments by colour comparison with prepared solutions of aminoazobenzene were not successful. In some cases the amount of aminoazobenzene required to produce a solution of similar colour exceeded the weight of diazoaminobenzene used in the experiments. The explanation lies, possibly, in the existence of yellow and violet salts of aminoazobenzene in different proportions in the two solutions (Cf. Hantzsch and Hilscher, Ber. 1908, *41*, 1171).

Conversion of diazoaminobenzene into aminoazobenzene.

To a solution of pure diazoaminobenzene (2 grams) in alcohol (80 cc.) a solution of hydrochloric acid (specific gravity 1.168 at 14° C.; 0.3 cc.) in alcohol (40 cc.) was

added, and the mixture allowed to stand in the ice chest for three weeks. The solution had then acquired a deep orange-red colour, and no longer gave the characteristic bluish red colour on the addition of alkali. It was allowed to evaporate at room temperature, redissolved in alcohol to which a little ammonia had been added and filtered. An excess of hydrochloric acid (equal volumes concentrated acid and water) was then added, and after standing the precipitated aminoazobenzene hydrochloride was filtered off and dried in air (1.4 grams). A further quantity (0.3 grams) was obtained by diluting the mother liquor with an equal volume of water. The total yield was, therefore, about 72 per cent. of the theoretical. From the hydrochloride the free base was liberated by dissolving in alcoholic ammonia and pouring the solution into excess of dilute aqueous ammonia. So obtained, the crude base melted at 116° C.; after one recrystallisation from ligroin the melting point was raised to 124-5° C.

Complete hydrolysis without conversion into aminoazobenzene.

A mixture of hydrochloric acid (10 cc. concentrated acid, S.G. 1.168 at 14° C.) and alcohol (30 cc.) was heated to boiling under a reflux condenser and a solution of pure diazoaminobenzene (2.0 grams) in alcohol (80 cc.) added during a period of three-quarters of an hour. The solution became reddish in colour and a copious evolution of gas took place. After a further fifteen minutes' boiling the mixture was cooled and its colour compared with known solutions of aminoazobenzene in alcoholic hydrochloric acid of the same concentration. By this means it was estimated that the amount of aminoazobenzene formed amounted to 0.024 grams, equivalent to 1.2 per cent. of the diazoaminobenzene used. For reasons dealt with in connection with the estimation of "diazo" nitrogen, this value is probably too high.

Modified method of preparation of diazoaminobenzene.

Redistilled aniline (9.2 grams) was mixed with a solution of sodium nitrite (7.0 grams) in water (40 cc.) and alcohol (30 cc.) added to bring about complete solution. A slow stream of carbon dioxide was passed in for 24 hours, by which time the mixture contained a mass of crystals. These were filtered off, and carbon dioxide passed into the filtrate for a further 48 hours or more when a further separation of crystals occurred. Each fraction was redissolved in alcohol, the solution filtered, and water added until crystallisation commenced. By this means 7.1 grams of golden-yellow crystalline material was obtained, melting at 99° C. Further purification by recrystallisation from alkaline alcohol yielded the product in the form of long, lemon-yellow needles, which gave only a very slight colour with an alcoholic potash solution. The pure product melted at 99.5-100° C.

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NOTE ON THE LEAF OIL FROM *DACRYDIUM FRANKLINI*, HOOKER.

By

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(Read before the Royal Society of New South Wales, 6th Nov., 1929.)

During an investigation of the leaf oil from *Dacrydium Franklini*, Hooker, Baker and Smith ("A Research on the Pines of Australia," p. 397), noted the presence, in addition to *l*-α-pinene, *d*-limonene and methyl eugenol, of a new hydrocarbon, to which they gave the name dacrydene. This hydrocarbon was characterised by the preparation of a crystalline nitrosochloride, m.p. 120-121°, but its constitution was not determined. On considering the constants of this hydrocarbon it occurred to us that possibly it was identical with either Δ^3- or Δ^4-carene, and we decided therefore to subject the hydrocarbon oil to a renewed examination.

We have been able to confirm the presence of *l*-α-pinene and *d*-limonene, and we have found also that the fraction b.p. 161-171° contains a small quantity of β-pinene. The yield of nopinic acid obtained on the oxidation of this fraction is extremely small, and it was obvious that some other constituent was present. The careful examination of this fraction from three different specimens of the oil failed to reveal the presence of Δ^3-carene, but on one occasion on oxidation with potassium permanganate, a small quantity of liquid acid yielding a crystalline semicarbazone,

m.p. 182°, was isolated. As this is the melting point of one of semicarbazones of 1:1-dimethyl-2-γ-ketobutyl*cyclo*-propane-3-carboxylic acid, an oxidation product of Δ^4-carene, the presence of this hydrocarbon seemed probable.

Gibson and Simonsen (*J.C.S.*, 1929, 305, 909) have shown recently that a very convenient method for the detection of the carenes consists in the oxidation of the appropriate fraction of the oil with Beckmann's chromic acid mixture, when *trans*-caronic acid is obtained in a comparatively good yield. On applying this method of analysis we have succeeded in obtaining *trans*-caronic acid, m.p. 202°, which was probably the laevorotatory acid (see p. 5). We conclude, therefore, that Baker and Smith's dacrydene is in all probability identical with Δ^4-carene, and it is possible that the crystalline nitrosochloride which they prepared, is actually a derivative of this hydrocarbon, although we have been unable to confirm this. This conclusion receives support from a comparison of the constants of the two hydrocarbons.

	d-Δ^4-*Carene*	*Dacrydene*
b.p.	165.5-167°/707 mm.	165-166°
d	$d_{30°}^{30°}$ 0.8552	$d^{20°}$ 0.8524
$n_D^{30°}$	1.474	1.4749
D	+62.2°	+14.48°

We would suggest that the name dacrydene be removed from the literature until evidence of its separate existence be forthcoming.

Experimental.

A quantity of the air-dried leaves of *Dacrydium Franklini* was procured from the west coast of Tasmania early in 1927.

The oil obtained from this material was used for this investigation, but in order to secure confirmation of the results it was deemed advisable to examine oils from further consignments. Consequently the publication of the results was delayed pending receipt of additional lots of leaves both in 1928 and 1929.

The critical examination of the essential oils from the two last consignments afforded confirmation of the original results. The crude distillates were in every instance divided into 2 portions, one lot being examined in Sydney, and the other in London.

For reference purposes the chemical and physical characters of the various lots of leaves are set forth in the following Table, marked No. 1.

A preliminary fractionation of the oil (1st lot, 25/3/1927), under diminished pressure, gave the results shown in Table 2.

TABLE 2.

No.	B.P. (20 mm.)	$d_{15°}^{15°}$	$\alpha_D^{20°}$	$n_D^{20°}$	Yield %
(i)	60-65°	0.8583	−16.9°	1.4675	18
(ii)	65-68°	0.8555	+4.5°	1.4691	30
(iii)	68-74°	0.8528	+33.3°	1.4716	27
(iv)	70-155°/10 mm.	0.9496	+17.4°	1.5060	12
(v)	residue	0.9708	−17.2°	1.5244	11

The terpene fraction of the oil was redistilled at the ordinary pressure using a twelve pear still head, with the following results:

TABLE 3.

No.	B.P. (769 mm.)	$d_{15°}^{15°}$	$\alpha_D^{20°}$	$n_D^{20°}$	Yield %
(i)	155-157°	0.8597	−31.75°	1.4666	11
(ii)	157-159°	0.8592	−25.5°	1.4680	9
(iii)	160-165°	0.8562	−4.1°	1.4690	18.5
(iv)	165.5-169°	0.8522	+31.6°	1.4713	9
(v)	169-174°	0.8511	+52.0°	1.4726	12.5

TABLE 1.

Date	Locality	Weight of Leaves	Yield of Oil	$d \frac{15^\circ}{15}$	$a^{20^\circ}_{D}$	$n^{20^\circ}_{D}$	Solubility in 80% Alcohol (by weight)	Ester No. $1\frac{1}{2}$ hrs. hot sap.	Ester No. after Acetylation	Remarks.
25/3/1927	Burnie, Tas.	245lbs.	0.76%	0.8799	+ 8.4°	1.4805	Insol. 10 vols.	2.7	36.9	Forwarded by Conservator of Forests, Tasmania.
12/4/1928	Strahan, Tas.	219lbs.	0.43%	0.8752	+18.6°	1.4805	do.	2.8	16.6	Forwarded by W. G. Andrewartha, Strahan, Tasmania.
8/4/1929	Zeehan, West Coast Tas.	130lbs.	0.3%	0.8911	+ 9°	1.4871	Insol. 10 vols.	4.5	27.3	Forwarded by Conservator of Forests, Tasmania.

An examination of these fractions showed the presence of *l*-α-pinene, a trace of β-pinene and of *d*-limonene, but no crystalline nitrosochloride, m.p. 120°, could be prepared, and no evidence was obtained of the presence of Δ^3-carene.

In view of these negative results a second sample of the terpene fraction of the oil was subjected to a more prolonged fractionation (five distillations) with a column. It will be observed from the results summarised in Table 4 that the fractions b.p. 161-171° tend to become very small.

TABLE 4.

	First Fractionation.		Fifth Fractionation.	
No.	B.P. (774 mm.)	Yield %	B.P. (774 mm.)	Yield %
(i)	158-161°	24 3	157-160°	36.5 $[d]_{5461} - 29.91°$
(ii)	161-165°	24	160-163°	10.4
(iii)	165-171°	28.6	163-169°	11.5
(iv)	171-185°	16.6	169-176°	41.1 $[d]_{5461} + 79°$
(v)	Residue (by difference)	6.5		0.5

Fraction 1.—Owing to its high optical activity, Fraction 1 only gave a small yield of α-pinene nitrosochloride (m.p. 109°) and the presence of this hydrocarbon was, therefore, confirmed by oxidation to pinonic acid. (See this Journal, Vol. LVI, page 195.) The acid soon solidified, and on recrystallisation from petroleum ether (b.p. 50-60°), melted at 70°. 1.059 grams dissolved in 10 c.c. chloroform gave a reading of $-10.2°$. $[\alpha]_D^{20°} = -96.31°$. The semicarbazone prepared in the usual manner melted at 207°. A small quantity of nopinic acid was separated from the oxidation acids.

Fractions 2 and 3.—On oxidation with potassium permanganate, nopinic acid was separated as its sparingly soluble sodium salt. 10 c.c. each of the respective terpene fractions were oxidised with 24 grams potassium permanganate in the presence of 5 grs. sodium hydroxide, 200 grs.

ice, and 1200 c.c. iced water. After completion of the reaction the mixture was saturated with carbon dioxide, the manganese sludge removed by filtration, and the filtrate evaporated to a small bulk in the presence of carbon dioxide.

The small quantity of sparingly soluble sodium salt was separated, and on decomposition with dilute sulphuric acid solution and extraction with benzene, it yielded only a trace of nopinic acid to the solvent.

The filtrate from the sodium nopinate was acidified with dilute sulphuric acid and the liberated acids extracted with chloroform. On removal of the solvent, a liquid acid closely resembling pinonic acid was obtained. It was converted directly to the semicarbazone, which proved to be more soluble in alcohol and of a different crystalline character to that obtained with pinonic acid. It melted at 182°.

In view of this result a quantity of the oil, b.p. 163-168° at 755 mm. (30 c.c.) was oxidised with Beckmann's chromic acid mixture under the conditions used by Gibson and Simonsen (loc. cit.). The oxidation acids so obtained partially crystallised on keeping. The solid was collected, m.p. 197-199°, and purified by crystallisation from hot water, when it separated in glistening prisms, m.p. 201-202°, and this melting point was not depressed on admixture with *l-trans*-caronic acid. Unfortunately the acid was not available in sufficient quantity for its rotation to be determined, but since the melting point remained unaltered on admixture with the laevorotatory acid, there can be little doubt that it was the *l-trans*-acid, showing it to be derived from the dextrorotatory hydrocarbon. The composition was confirmed by a titration. (Found M., 160; calc. M., 158.)

Fraction 4 was identified as *d*-limonene by the preparation of the tetrabromide, m.p. 104-105°, and dipentene dihydrochloride, m.p. 48-50°, both alone and when mixed with an authentic specimen.

Residue, Table 2, page 98.—It is interesting to record that the high boiling residue from the first lot of oil (25/3/1927) solidified when kept in the ice-chest for a prolonged period.

The crystalline mass was placed on a porous tile kept at 15° and the resultant crystals purified by recrystallisation from acetone, an excellent solvent for the purpose. Combustion and molecular weight results showed it to be a diterpene, $C_{20}H_{32}$, possessing a specific rotation in chloroform solution of +18.9°. It melted at 95° and is undoubtedly identical with Phyllocladene referred to in "Pines of Australia," by Baker and Smith, pages 422-426. It has not previously been recorded as a constituent of the leaf oil of Dacrydium Franklini.

We desire to thank Prof. C. S. Gibson, O.B.E., for determining the rotatory power of the pinene and limonene fractions, and also for providing facilities for carrying out a portion of the work in his laboratory, and Mr. F. R. Morrison, A.A.C.I., F.C.S., for assistance in the determination of the constants of the crude oils and various fractions.

We are also indebted to the Conservator of Forests, Hobart, Tasmania, for kindly furnishing the necessary supplies of leaf material.

THE ESSENTIAL OILS OF *MELALEUCA DECORA* (SALISBURY) DRUCE, AND *M. NODOSA* VAR. *TENUIFOLIA* (DE CANDOLLE), FROM THE PORT JACKSON DISTRICT.

PART I.

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(With Plates VII-IX.)

(Read before the Royal Society of New South Wales, 6th Nov., 1929.)

These two species of Melaleuca occur widely distributed throughout eastern Australia, being especially abundant in certain parts of the Port Jackson District of New South Wales.

We have, as yet, only had an opportunity of examining material from the Liverpool District, about 20 miles south of Sydney. The rapid advancement of settlement foreshadows the probable early extermination of these two tea trees, despite the very extensive areas which they cover.

The examination of the essential oils was commenced in 1922, but pressure of other work precluded our devoting the necessary time to an exhaustive examination of material collected from different localities. We considered it advisable, under the circumstances, to record at an early date the results obtained from material collected in the Port Jackson District.

Both species are tall shrubs or trees possessing paper barks, and grow together in the Liverpool District, mainly in situations of a swampy character.

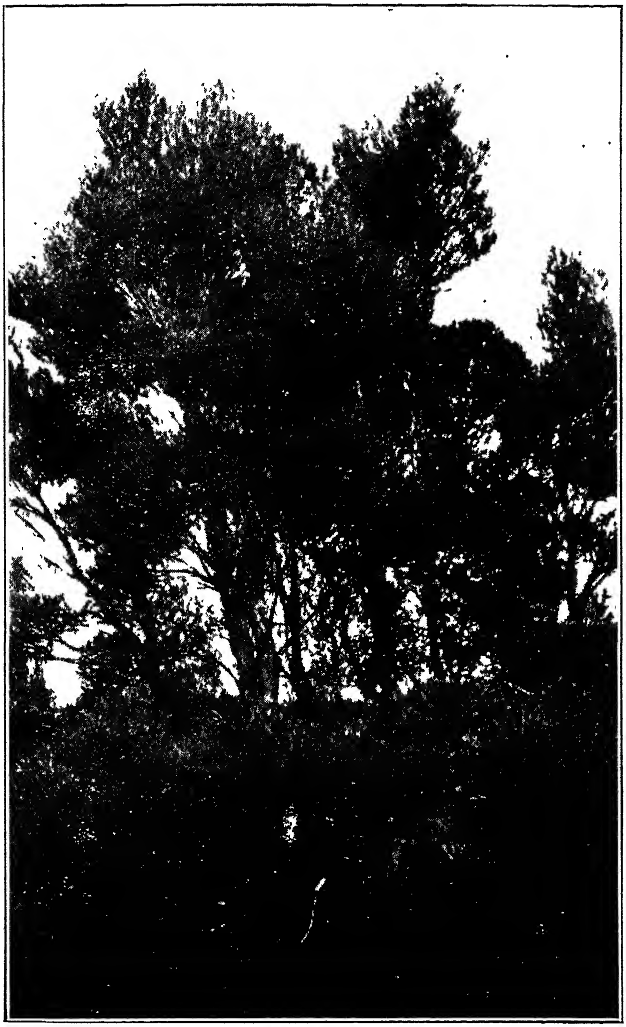

Plate VII.

A typical tree of *Melaleuca decora* growing in the Liverpool District, New South Wales.

Plate VIII.

Large tree of *Melaleuca decora* at Guildford, New South Wales. Note the "Tea Tree" scrub in background.

MELALEUCA DECORA (Salisbury), Druce.

This tall paper bark tea tree grows to a height of 30 feet, and is identical with *Melaleuca genistifolia* (Smith). The species was first named by Salisbury and published in "Prodomus" (1796), page 352, under the name of Metrosideros. It is not identical with *Melaleuca genistifolia* (Smith) examined by Messrs. Baker and Smith (see Proc. Royal Society of N.S.W., Vol. XLV (1911), pages 365/369), which in the opinion of Mr. E. Cheel, Curator of the National Herbarium, Sydney, is identical with *Melaleuca lanceolata* (Otto).

The botanical features of the species are also referred to in Bentham's "Flora Australiensis," Vol. III, page 143.

The trees from which leaves were obtained for oil distillation purposes did not exceed 15 to 20 feet in height, a good proportion of them being regrowth on previously cleared country.

Plate VII affords a good indication of the nature and habit, character of leaves, etc., of an average tree of this species occurring in the Liverpool District.

The tree shown in Plate VIII is of exceptional size, being not less than 50 ft. in height. It is one of several growing at Guildford which have been preserved on private property for shade purposes. The size and luxuriant nature of the tree is probably due to the removal of "scrub" from its immediate neighbourhood, thus affording ideal conditions for its full development.

Typical "Tea Tree" scrub, consisting mainly of *Melaleuca nodosa*, var. *tenuifolia*, is depicted in the background.

The Essential Oil.

The essential oils were of a bright yellow colour with a pronounced odour of pinene and sesquiterpene. Altogether 677 lbs. weight of leaves and terminal branch-

lets, cut as for commercial purposes, yielded on steam distillation an average of 0.23%, varying from 0.12% to 0.31%, the lower yield being obtained from material collected at a very dry period.

The principal constituents which have so far been identified are d-α-pinene (50/60%) and sesquiterpenes (25/30%), together with small quantities of a-terpineol ?, dipentene and sesquiterpene alcohol.

Experimental.

Six hundred and seventy seven lbs. weight of the leaves and terminal branchlets from Cabramatta, near Sydney, yielded on distillation with steam, crude oils possessing the chemical and physical characters shown in the following tables:

On distillation the crude oils behaved as follows, viz.:

22/8/1922 241 c.c. at 10 mm.:—50% at 62-65°, 14% at 65-120°, and 35% between 120-140°.

30/1/1923 300 c.c. at 10 mm.:—62% below 65°, 18% at 65-129° and 18% between 130° (4 mm.) and 140° (5 mm.).

Determination of α-pinene.

The fractions distilling below 65° and 10 mm. were repeatedly redistilled over metallic sodium at 770-774 mm., when the greater portion distilled below 160°.

The following fractions were obtained with the second consignment, viz.:

Boiling Point.	Volume.	$d_{15}^{15°}$	$\alpha_D^{20°}$	$n_D^{20°}$
155-157°	95 c.c.	0.8627	+24.25°	1.4674
157-158°	17 c.c.	0.8627	+20.5°	1.4686
158-160°	12 c.c.	0.8630	+16.75°	1.4696

32 c.c. of Fraction 155-157° were oxidised with potassium permanganate by the method described in this Journal (Vol. LVI (1922), page 195). The crude pinonic acid isolated therefrom was purified by recrystallisation from

MELALEUCA DECORA (Salisbury), Druce.

Date.	Locality.	Weight of Leaves	Yield of Oil.	$d\frac{15^\circ}{15}$	$a_D^{20^\circ}$	$n_D^{20^\circ}$	Solubility in 80% Alcohol (by weight).	Ester No. Hot Sap.	Ester No. 1½ Hrs. Hot Sap, after Acetylation.
15/8/1922	Cabramatta near Sydney	lbs. 305	0.25%	0.8915	+12.52°	1.4810	insol. 10 vols.	9.3	35.2
30/1/1923	do. do.	235	0.31%	0.8895	+13.25°	1·4785	do.	8.1	30.4
18/12/1928	do. do.	137	0.12%	0.9069	+12.2°	1.4872	do.	11.9	52.6

MELALEUCA NODOSA var. TENUIFOLIA.

Date.	Locality.	Weight of Leaves.	Yield of Oil.	$d_{15}^{15^\circ}$	$a_D^{20^\circ}$	$n_D^{20^\circ}$	Solubility in 70% Alcohol-	Ester No. 1½ Hours Hot Sap.	Ester No. after Acetylation.	Cineol (Phos. Acid Method),
15/8/1922	Cabramatta, near Sydney,	lbs. 276	1.0%	0.9125	+5.15°	1.4641	Soluble in 1.3 vols.	3.5	40.7	55%
30/1/1923	do. do.	110	0.9%	0.9073	+7 75°	1.4649	Soluble in 5.5 vols.	5.8	40.7	40%

petroleum ether, B. pt. 55-60°. It proved more than usually soluble in that solvent and was found to be the inactive form. The pinonic acid melted at 104-105°, and a solution in chloroform was found to be optically inactive. The semicarbazone prepared therefrom melted at 207-208°.

Fraction 157-158° was treated with dry hydrochloric acid gas at − 20° and the solid hydrochloride thus prepared was separated, dried and recrystallised from absolute alcohol. It melted at 130-131°. 0.6694 gram in 10 c.c. alcohol gave a reading of +1°, $[\alpha]_D^{20°} = +15°$.

Determination of dipentene.

The residues remaining in the flask after the distillation of *d*-*α*-pinene distilling below 160° were worked up and a small quantity of liquid distilling at 168-176° was isolated. The amount was too small for determination of its physical constants, but on account of the characteristic odour, it was dissolved in acetic acid and brominated at − 20°. On standing in the ice-chest overnight a small quantity of crystals separated. These were purified from ethyl acetate and the melting point determined as 123-124°, thus affording evidence of the presence in small quantity of dipentene.

Occurrence of a-terpineol.

In the course of redistillation of that portion of oil distilling above 65° at 10 mm., a small fraction, measuring 10 c.c. (ex 300 c.c. crude oil) was separated. It possessed the following characters:

B. pt. 80-100° (10 mm.) (principally 90-96°);

$d_{15°}^{15°}$ 0.9063, $\alpha_D^{20°}$ − 8.85°, $n_D^{20°}$ 1.4842.

It reacted with both phenylisocyanate and napthylisocyanate, but no definite urethane could be isolated. In view of the occurrence of a-terpineol in oils of this nature and the definite determination of the alcohol in the oil

of *M. nodosa*, var. *tenuifolia*, there is every indication of its presence in the essential oil, although experimental evidence in support thereof could not be obtained.

Determination of sesquiterpenes.

The fractions distilling between 120-140° (5 mm.) were subjected to repeated fractionation over metallic sodium, when the following distillates were obtained, viz.:

Boiling Point.	Volume.	$d_{15}^{15°}$	$a_D^{20°}$	$n_D^{20°}$
100-120° (10 mm.)	10 c.c.	0.9146	−1 2°	1.4942
120-125° (5 mm.)	7 c.c.	0.9217	+2.85°	1.4990
120-125° (5 mm.)	35 c.c.	0.9281	+7.7°	1.5021

All three fractions gave the usual colour reactions with bromine in acetic acid solutions and sulphuric acid in acetic anhydride solution, characteristic of sesquiterpenes.

The third fraction did not yield a crystalline hydrochloride but on dehydrogenation with sulphur at 210-215° a good yield of azulene resulted. The identity of the latter was confirmed by the preparation of the picrate, which melted at 117-118° and by its crystalline characteristics when examined with the microscope.

MELALEUCA NODOSA var. TENUIFOLIA.

The botanical features of this tea tree, which also possesses a paper bark, are described in Bentham's "Flora Australiensis," Vol. III, page 158.

It is a tall shrub, usually attaining a height of 6 to 10 feet, and possessing rigid spiny pointed leaves (Plate IX). It occurs in dense masses, forming what is generally called "Tea Tree Scrub," an idea of which can be formed from Plate VIII, which shows a mass of this species in the background.

The very extensive areas of "Tea Tree" scrub growing at Cabramatta and Guildford in the Liverpool District

consist almost entirely of this species, with a limited number of trees of *Melaleuca decora* intermingled therewith. It might possibly have been a commercial proposition some years ago to have distilled this species, but the rapid spread of population and the consequent destruction of large areas has rendered its utilisation very improbable.

The Essential Oils.

The essential oils were of a pale lemon yellow colour with a pleasant odour of cineol modified by the terpenes and alcohol and closely resembled in general characters commercial eucalyptus oil containing cineol. Altogether 386 lbs. weight of leaves and terminal branchlets, cut as for commercial purposes, yielded on steam distillation an average yield of oil of 1%. The principal constituents which have so far been identified are cineol (40-55%), α-pinene, dipentene, a-terpineol, sesquiterpene, etc.

Experimental.

Three hundred and eighty six pounds weight of leaves and terminal branchlets collected at Cabramatta, near Sydney, yielded on distillation with steam crude oils possessing the chemical and physical characters shown in the following table:

300 c.c. crude oil, 30/1/1923, behaved as follows on distillation at 10 mm.:

78% distilled below 65°, 9% at 65-85°,
6% at 85-110° and 6% between 110-140°.

Determination of terpenes.

The fractions distilling below 65° at 10 mm. and at 65-85° were redistilled several times and the three undermentioned portions were finally separated, viz.:

Boiling Point.	Volume.	$d_{15}^{15°}$	$\alpha_D^{20°}$	$n_D^{20°}$
50-57° (10 mm.)	75 c.c.	0.8947	+11.65°	1.4626
57-62° (10 mm.)	112 c.c.	0.9019	+ 6.3°	1.4624
62-68° (10 mm.)	58 c.c.	0.9086	+ 2.6°	1.4627

Plate IX.

Typical tree of *Melaleuca nodosa*, var. *tenuifolia*, growing in Liverpool District, New South Wales.

All three fractions appeared to be rich in cineol, as the last two had congealing points of $-18°$ and $-16°$ respectively. Treatment with 50% resorcin solution, however, in order to effect the removal of this constituent, proved very difficult, owing to the cineol-resorcin compound separating as a solid crystalline mass. It required the use of large volumes of resorcin solution to effect the separation of quite small quantities of terpenes for identification.

Finally 52 c.c. of crude terpenes were separated, which on distillation over metallic sodium at 763 mm. yielded the following fractions, viz.:

Boiling Point.	Volume.	$d_{15}^{15°}$	$\alpha_D^{20°}$	$n_D^{20°}$
155-160°	23 c.c.	0.8583	+28.85°	1.4676
161-167°	17 c.c.	0.8565	+18.3°	1.4696

The first fraction gave a good yield of pinene nitrosochloride of melting point 114-115°. The presence of this terpene was confirmed by the preparation of the hydrochloride, which melted at 125-126°.

The second fraction was examined for β-pinene with negative results. The liquid acid resulting from the oxidation with potassium permanganate in the presence of sodium hydroxide yielded a semicarbazone of melting point 208-210°. It was found to be a mixture of α-pinene with dipentene.

Fraction 161-167°, together with a portion distilling between 168-176°, yielded on treatment with bromine in glacial acetic acid a good yield of tetrabromide of melting point 124-125°. The terpenes present, therefore, consisted of α-pinene and dipentene.

Determination of cineol.

The resorcin washings were subjected to steam distillation and the regenerated cineol purified by distillation

over metallic sodium. The colourless liquid of camphoraceous odour thus obtained gave the following constants on examination, viz.:

Boiling point, 174-176° (764 mm.), $d_{15}^{15°}$ 0.9297 $\alpha_D^{20°}$ +0.25°, $n_D^{20°}$ 1.4585, congealing point −1.25°, melting point +0.5°. Its reaction with phosphoric acid and iodol confirmed its identity.

This constituent was quantitatively determined in the crude oils by the phosphoric acid method immediately after distillation.

Determination of a-terpineol.

The fractions distilling between 65-85° (10 mm.) and 85-110° (10 mm.) were redistilled until finally a portion (10 c.c.) distilling at 98-102° at 10 mm. was collected for examination. It had $d_{15}^{15°}$ 0.9265, $\alpha_D^{20°}$ +11° and $n_D^{20°}$ 1.4815, and on treatment with napthylisocyanate gave an excellent yield of napthylurethane melting at 144-146°, thus confirming its identity with a-terpineol.

Sesquiterpenes.

The high boiling fraction distilling between 110-140° at 10 mm. representing 6% of the crude oil had $d_{15}^{15°}$ 0.9423, $\alpha_D^{20°}$ +11.2° and $n_D^{20°}$ 1.4956.

The quantity available was altogether too small for thorough examination, but the well-known colour reactions with bromine in glacial acetic acid and sulphuric acid in acetic anhydride solutions, showed it to consist essentially of sesquiterpenes. Dehydrogenation with sulphur resulted in the production of azulene.

We are indebted to Mr. E. Cheel, Curator of the National Herbarium, Sydney, for the botanical determination of the species referred to in this paper.

SOME MECHANICAL PROPERTIES OF AUSTRALIAN GROWN *PINUS INSIGNIS* (*P. RADIATA*).

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PART II.

(Read before the Royal Society of New South Wales, Dec. 4, 1929.)

Several years ago, through the courtesy of the Forestry Commission of New South Wales, timber specimens of *Pinus insignis* (*P. radiata*) were obtained from Gosford and Sutton Forest, New South Wales; Creswick, Victoria; and Wirrabara and Mt. Gambier, South Australia. A number of static bending and Izod impact tests were made, and the results published in a paper read before this Society.* Subsequently the necessary apparatus for the making of compression, shear, cleavage, tension and hardness tests, in conformity with the standard practice first adopted by the United States Forest Products Laboratory, and subsequently by most similar institutions in the British Empire,† was obtained. A further series of tests on small clear specimens has been made with the following results:—

Compression Parallel to the Grain.

Size of test specimens 2in. x 2in. x 8in.

*Welch, M.B. Some mechanical Properties of Australian Grown *Pinus insignis* (*P. radiata*), Proc. Roy. Soc. N.S.W., lxi, 354-370, 1927.

†Mechanical and Physical Properties of Timbers. Tests on small clear specimens, Project No. 1, Forest Products Research Laboratory, Dept. of Scientific and Industrial Research, London, 1928.

Gosford.

	C_1	C	E	W	r.p.i.	L.W.	M
Max. ..	4500	5825	1,710,000	42.6	5.5	30	13.2
Min. ..	2500	5075	980,000	37.9	4.0	25	12.6
Mean (6 tests)	3385	5330	1,330,000	40.8	4.4	27	12.9

Sutton Forest.

	C_1	C	E	W	r.p.i.	L.W.	M
Max. ..	3850	7320	3,750,000	35.1	5.0	30	13.8
Min. ..	2800	5050	1,170,000	28.3	2.0	10	13.4
Mean (6 tests)	3175	6085	2,160,000	31.9	3.1	18	13.6

Creswick.

	C_1	C	E	W	r.p.i.	L.W.	M
Max. ..	4750	7240	3,030,000	37.4	8.0	25	13.6
Min. ..	3000	5370	1,620,000	29.9	4.0	15	13.4
Mean (6 tests)	3475	6525	2,430,000	34.3	6.1	21	13.5

Wirrabara.

	C_1	C	E	W	r.p.i.	L.W.	M
Max. ..	4700	6340	2,220,000	29.6	6.5	15	13.8
Min. ..	2200	4570	1,130,000	27.0	4.5	10	13.2
Mean (5 tests)	3585	5520	1,834,000	27.9	5.7	12	13.5

Mt. Gambier.

	C_1	C	E	W	r.p.i.	L.W.	M
Max. ..	4000	6270	2,604,000	31.2	4.5	25	13.8
Min. ..	1500	4000	1,170,000	27.0	2.0	12	13.6
Mean (6 tests)	3080	5435	1,872,000	29.9	3.1	19	13.7

C_1 = Compressive stress at proportional limit in lbs. per sq. in.

C = Crushing strength at maximum load in lbs. per sq. in.

E = Modulus of elasticity in lbs. per sq. in.
W = Weight per cubic foot in lbs. at time of testing.
r.p.i. = Number of growth rings per inch.
L.W. = Average percentage of late wood in the growth ring.
M = Percentage moisture content at time of testing, calculated on the dry weight.

The results show that the wood is weak in compression in comparison with air dry Oregon or Douglas Fir, *Pseudotsuga taxifolia,* for which values for C_1 are given as 4220 and 7290 lbs. per sq. in.; and for C, 7600 and 8885 lbs. per sq. in., by Canadian* and U.S.A.† authorities respectively.

The weights per cubic foot for the Oregon used in the tests quoted are 29.1 and 29.6 lbs., whereas the mean for the *Pinus insignis* is 33 lbs. per cubic foot.

Taking into consideration the much greater density of the Gosford wood (40.8 lbs. per cubic foot), one would have expected the timber to have shown greater strength in compression, in comparison with the other material, whilst actually it is the weakest in ultimate crushing strength. An almost similar result was obtained from the static bending tests given in Part 1, where the heavy Gosford wood was found to be by no means the strongest as a beam, although it possessed remarkable toughness, and in shock absorbing ability easily outclassed the other material. The Creswick grown wood proved to give the maximum ultimate compressive strength and the greatest modulus of elasticity, and incidentally to have the slowest average

*Some Commercial Softwoods of British Columbia, McElhanney and Perry, Forest Service Bulletin No. 78, Dept. of the Interior, Canada, 1927.

†Mechanical Properties of Woods grown in the United States, Newlin and Wilson, U.S. Dept. Agric. Bull. No. 556, 1917.

rate of growth, whilst that from Wirrabara showed the greatest compressive strength at the proportional limit and ranked next to Creswick in slowness of growth.

Compression Perpendicular to the Grain.

GOSFORD.

	C_p	W	r.p.i.	L.W.	M
Max.	1625	40.8	5.0	30	15.8
Min.	1100	37.1	2.0	15	14.4
Mean (7 tests) ..	1300	39.5	3.6	24	15.1

4 radial, 4 tangential.

SUTTON FOREST.

	C_p	W	r.p.i.	L.W.	M
Max.	1050	33.5	5.0	25	15.7
Min.	825	30.3	2.5	12	15.1
Mean (8 tests) ..	1060	31.9	3.3	19	15.4

CRESWICK.

	C_p	W	r.p.i.	L.W.	M
Max.	1160	37.5	6.0	25	15.0
Min.	850	31.4	3.5	20	14.2
Mean (6 tests) ..	985	34.3	4.7	23	14.6

WIRRABARA.

	C_p	W	r.p.i.	L.W.	M
Max.	1000	32.0	6.5	15	13.6
Min.	500	27.5	4.5	6	13.3
Mean (12 tests) ..	800	29.0	5.8	11	13.5

MT. GAMBIER.

	C_p	W	r.p.i.	L.W.	M
Max.	1175	31.2	6.0	25	13.2
Min.	650	26.0	1.5	10	13.2
Mean (13 tests) ..	885	28.9	2.9	17	13.2

	C_p	W	r.p.i.	L.W.	M
Mean (46 tests) ..	970	31.9	4.1	17	14.1

C_p = Compressive stress at proportional limit in lbs. per sq. in.

W, r.p.i., L.W. and M as in compression parallel to grain.

The value of C_p is obtained by measuring the deflections at varying loads, using a plate 2 inches wide on a specimen 2 inches in width, and giving a bearing surface of 4 square inches. The proportional limit is determined from the usual stress-strain diagram. In approximately half of the above tests the load was applied on a radial surface, and on the other half, tangentially.

The mean result, with the load applied to the radial surface (22 tests), was 1040 lbs. per sq. in., and to the tangential face (24 tests), 975 lbs. per sq. in.; the difference is not very great, and might be accounted for by individual variation of the test pieces. It would be natural, however, to expect the wood to resist compression better when the radial plane is the bearing surface, due to the stiffening effect of the growth rings on edge.

The value of this test is as an indication of the safe bearing surface for joists, etc.

Results obtained from Canadian and U.S.A. tests (l.c.), are respectively 997 and 1085 lbs. per sq. in., indicating that Oregon is somewhat stronger in this direction than the *Pinus insignis* which was tested. The harder and denser Gosford wood shows a definite superiority over that from other localities in spite of the comparatively high moisture content, but the comparatively light-weight wood from Sutton Forest is stronger than the denser Creswick material.

Shear Parallel to Grain.

GOSFORD.	S	W	r.p.i.	L.W.	M
Max.	1950	41.3	6.0	30	12.7
Min.	1660	37.6	2.0	20	12.6
Mean (10 tests) ..	1810	39.7	3.9	24	12.7

SUTTON FOREST.	S	W	r.p.i.	L.W.	M
Max.	1710	34.5	5.0	25	13.6
Min.	1350	30.3	2.5	15	13.4
Mean (10 tests) ..	1540	32.1	3.7	22	13.5

CRESWICK.	S	W	r.p.i.	L.W.	M
Max.	1830	37.9	6.5	25	13.6
Min.	1250	31.4	4.0	18	13.4
Mean (12 tests) ..	1620	33.9	4.6	22	13.5

WIRRABARA.	S	W	r.p.i.	L.W.	M
Max.	1745	32.0	6.5	15	13.3
Min.	1225	27.5	4.5	6	12.7
Mean (14 tests) ..	1470	28.6	5.8	12	13.0

MT. GAMBIER.	S	W	r.p.i.	L.W.	M
Max.	1830	31.0	6.0	25	13.3
Min.	1360	26.0	1.5	10	12.9
Mean (13 tests) ..	1560	27.2	2.9	17	13.1

	S	W	r.p.i.	L.W.	M
Mean (59 tests) ..	1590	32.2	4.3	19.1	13.2

S = Shearing strength, parallel to grain, in lbs. per sq. in.

W, r.p.i., L.W. and M as in compression parallel to grain.

Comparative figures for Oregon from Canadian and U.S.A. tests are 1270 and 1175 lbs. per sq. in. respectively. The shearing strength shown by these tests, which is greater than that of Oregon, indicates the resistance to slipping of one part of the wood over another, and is important in joints in building timbers. The Gosford grown wood is again strongest, the wood possessing considerable ability to resist longitudinal shear, followed by Creswick and Mount Gambier, the latter possessing a very satisfactory figure considering the comparatively low density and rapid

growth. Approximately the same number of tests were made with the plane of shear in radial and tangential planes; the mean results were plane of shear radial (28 tests), 1565 lbs. per sq. in.; plane of shear tangential (31 tests), 1635 lbs. per sq. in. The difference is comparatively small; apparently a normal condition in softwoods.

Tension Perpendicular to Grain.

	T	W	r.p.i.	L.W.	M
GOSFORD.					
Max.	990	41.3	6.0	30	13.1
Min.	420	37.1	2.5	15	12.8
Mean (11 tests)	696	39.1	4.1	23	13.0
SUTTON FOREST.	T	W	r.p.i.	L.W.	M
Max.	650	34.5	5.0	25	13.8
Min.	215	30.3	2.5	12	13.2
Mean (9 tests)	460	31.9	3.5	22	13.5
CRESWICK.	T	W	r.p.i.	L.W.	M
Max.	725	37.5	7.0	25	14.8
Min.	335	30.6	3.5	15	13.8
Mean (11 tests)	514	33.5	4.8	20	14.3
WIRRABARA.	T	W	r.p.i.	L.W.	M
Max.	645	32.0	6.5	15	13.4
Min.	320	26.5	4.5	6	13.2
Mean (14 tests)	475	29.0	5.9	11	13.3
MT. GAMBIER.	T	W	r.p.i.	L.W.	M
Max.	945	31.0	6.0	25	14.1
Min.	280	26.0	1.5	10	14.0
Mean (12 tests)	488	29.0	3.0	18	14.1
	T	W	r.p.i.	L.W.	M
Mean (57 tests)	535	33.0	4.4	18	13.9

T = Strength in tension in lbs. per sq. in.

W, r.p.i., L.W. and M as in compression parallel to grain.

Results of tests made on air dry Oregon by Canadian and U.S.A. authorities (l.c.) are 539 and 325 lbs. per sq. in. respectively. The Gosford wood proved to be considerably stronger than the other material, there being comparatively little difference between the figures obtained for the timber from the other localities.

Tests were made on approximately the same number of specimens with the planes of failure radial and tangential; the actual results were, plane of failure radial, 485 lbs. per sq. in.; plane of failure tangential, 568 lbs. per sq. in. A somewhat greater strength in tension in a tangential plane is commonly found in timber, although in many woods there is comparatively little difference in strength in the two directions.

Cleavage.

	Cl.	W	r.p.i.	L.W.	M
GOSFORD.					
Max.	495	41.3	6.0	30	13.5
Min.	265	33.8	2.5	15	12.7
Mean (9 tests) ..	366	39.3	3.9	21	13.1
SUTTON FOREST.	Cl.	W	r.p.i.	L.W.	M
Max.	375	33.5	5.0	30	14.5
Min.	240	30.3	2.0	12	13.6
Mean (13 tests) ..	313	31.6	3.4	21	14.1
CRESWICK.	Cl.	W	r.p.i.	L.W.	M
Max.	435	37.9	6.5	25	13.8
Min.	230	31.4	3.5	18	12.7
Mean (12 tests) ..	311	33.5	4.7	21	13.3
WIRRABARA.	Cl.	W	r.p.i.	L.W.	M
Max.	360	32.0	6.5	15	14.2
Min.	100	26.5	4.5	6	13.2
Mean (13 tests) ..	277	29.0	6.0	11	13.7

MT. GAMBIER.	Cl.	W	r.p.i.	L.W.	M
Max.	395	31.0	6.0	25	15.5
Min.	210	27.0	1.5	12	13.6
Mean (11 tests) ..	284	29.3	3.2	18	14.6
	Cl.	W	r.p.i.	L.W.	M
Mean (58 tests) ..	308	31.4	4.2	18	13.7

Cl. = Cleavage or splitting strength per inch of width of specimen, in lbs.

W., r.p.i., L.W. and M as in compression parallel to grain.

Cleavage tests indicate the resistance of a wood to splitting, and furnish some idea of the ability to stand nailing, screwing and the driving of spikes, or the ease or otherwise with which the wood can be split for firewood, etc. Tests made in Canada (l.c.), on Oregon, are given as 265 lbs. per in. width. Cleavability may be largely affected by factors such as interlocked grain, though wood is usually more fissile in a radial plane than tangentially. The mean of 29 tests in each case showed a splitting strength of 343 lbs. per sq. in. width in a tangential plane, and 277 lbs. per in. width in 'a radial plane.

GOSFORD.	Ht.	Hr.	He.	W	r.p.i.	L.W.	M
Max.	1630	1540	1270	40.8	5.0	30	15.8
Min.	760	810	980	37.1	2.0	15	14.4
Mean (7 tests)	1190	1155	1095	39.5	3.6	24	15.1

SUTTON FOREST.	Ht.	Hr.	He.	W	r.p.i.	L.W.	M
Max.	600	710	930	33.5	5.0	25	15.7
Min.	460	500	690	29.1	2.0	7	15.1
Mean (8 tests)	545	610	700	31.2	3.3	17	15.4

CRESWICK.	Ht.	Hr.	He.	W	r.p.i.	L.W.	M
Max.	1000	990	1110	37.5	6.0	25	15.0
Min.	600	610	820	31.4	3.5	20	14.2
Mean (6 tests)	780	770	955	36.9	4.7	22	14.6

WIRRABARA.	Ht.	Hr.	He.	W	r.p.i.	L.W.	M
Max.	740	810	830	32.0	6.5	15	13.6
Min.	400	410	640	27.5	4.5	6	13.3
Mean (13 tests)	550	530	725	28.9	5.8	11	13.5

MT. GAMBIER.	Ht.	Hr.	He.	W	r.p.i.	L.W.	M
Max.	940	820	1010	31.0	4.0	25	13.2
Min.	340	390	610	26.0	1.5	10	13.2
Mean (13 tests)	600	580	840	28.9	2.9	17	13.2
Mean (47 tests)	688	680	836	31.6	4.1	17	14.1

Ht., Hr., and He. are the loads in lbs. required to imbed a ball 0.444 in. in diameter to half its diameter, on a tangential, radial, and end surface respectively.

W., r.p.i., L.W. and M as in compression parallel to grain.

The hardness of a timber is important since it indicates its ability to withstand bruising, and, to some extent, mechanical abrasion. At least a moderate degree of hardness is essential in joinery timbers, e.g., skirtings, door jambs and architraves, also in furniture, flooring, paving, blocks, rollers, etc. Hardness is largely influenced by the weight of the timber. Comparative figures for Oregon tested in Canada and U.S.A. (l.c.), are H (t & r) = 687 and 735 lbs., and He. = 799 and 835 lbs. respectively. The Gosford grown wood proved to be much harder than the others, and is equal in this respect to Pitch Pine (*Pinus spp.*). The Creswick material, also of high density, gave a high hardness figure. End hardness is usually higher than lateral hardness, and as the mean results show, the difference between the radial and tangential figures is not very appreciable.

SUMMARY.

A further series of tests shows that there is comparatively little difference in the mechanical properties of *Pinus insignis* and Oregon or Douglas Fir. Whilst the denser wood from Gosford was exceptionally tough, it was weaker

in some other respects than that from Creswick, notably in static bending and compression parallel to the grain. In compression perpendicular to the grain, shear parallel to the grain, tension perpendicular to the grain, cleavage and hardness the Gosford material proved superior. The results indicate that considerable variation in mechanical and physical properties occurs in the wood from different localities, and no doubt a similar variation will be found in individual trees in the same plantation, due to varying conditions of growth, just as the wood in one log may vary in strength and weight with its position in the tree. The tests are of some value in showing that the wood is not brittle and devoid of strength as is commonly believed. Whereas the denser Gosford wood resembles Pitch Pine, the lighter and milder South Australian wood possesses the characteristics generally of the White Pine group, which includes the Clear and Sugar Pines. It seems, therefore, that by proper grading, *Pinus insignis* can be obtained for many of the purposes for which imported coniferous softwoods are used, provided, of course, that it can be obtained in lengths free from defects.

Objections are frequently raised because of the presence of knots, but it is often difficult to find a lineal foot of Baltic Pine, *Picea excelsa,* as imported into this country in large quantities for flooring and lining, without a knot. Moreover, knots can be minimised by proper treatment during growth, although they certainly are characteristic of logs obtained from "back yard" plantations, and, unfortunately, on such logs most of the popular prejudice is based.

I am much indebted to Mr. F. B. Shambler, of the Museum Staff, for preparing the test specimens, and his assistance in making the tests, and to the Mechanical Engineering Department, Sydney Technical College, for the use of the necessary machines.

SOME PROPERTIES OF RED SATINAY, *SYNCARPIA HILLII.*

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(With Plates X and XI.)

(Read before the Royal Society of New South Wales, Dec. 4, 1929.)

Red Satinay or Fraser Island Turpentine, *Syncarpia Hillii*, Bailey*, was first described from Fraser Island, off the Queensland coast, and it is practically confined to this Island. Botanically it differs from Turpentine, *S. laurifolia,* an allied species, in its larger foliage and flowers and in being glabrous.

According to Swain† "a height of 130 feet and a girth of 180 inches is not uncommon, and there are giants of even more massive proportions." It is little known on the Sydney market, although Swain states that Queensland Forest Service field estimates are that 50,000,000 super feet are available, and with its ease of natural regeneration and rapid growth, rationed supplies can be maintained. A considerable amount of information as to its uses is given by Swain, who also mentions that the heartwood possesses great durability, and is resistant to white ants and borers.

In appearance it resembles Turpentine, *Syncarpia laurifolia*, or the red form of Brush Box, *Tristania conferta,* but is usually lighter in weight; like these woods it requires careful seasoning. One of the chief disadvantages is its

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* Bailey, F.M., Contributions to the Queensland Flora, Part II., Proc. Roy. Soc. of Queensland 1, 86, 1884.

† Swain, E. H. F., The Timber and Forest Products of Queensland, Brisbane, 1928.

comparatively high density, thus rendering it unsuitable for many purposes where weight is a consideration. Figured logs appear to have possibilities for veneer, but apparently do not cut satisfactorily whilst green, without steaming.

General Properties.

The close textured wood is typically dull reddish brown in colour, without pronounced sheen when straight grained, but lustrous when figured, due to reflection of the light from the surface of the undulating fibres. It possesses no natural figure, but may possess a high degree of accidental figure giving rise to fiddle mottle, ribbon grain, or a combination of these two. It is moderately hard and heavy, and whilst it is somewhat "gritty," and inclined to dull tools quickly, it works cleanly and planes crisply, with little tendency of the "grain" to tear up. In sawing or drilling it is inclined to "burn," but does not splinter, and is not tough or leathery, but has rather a tendency to be "short grained." It requires little filler, and readily takes a high polish. A high tannin content in the wood is indicated by the blue black colouration produced when the wet timber is worked with steel tools.

Gross Anatomy.

Pores small, but easily visible on end section with naked eye, almost uniformly distributed with some tendency to form oblique rows, frequently with very pale lemon yellow deposits, appearing as light coloured dots on end section or as short narrow lines on the surface. Soft tissue not apparent. Rays scarcely visible on end or tangential surfaces without lens, but conspicuous on a radial face, appearing darker in colour than the ground tissue. Growth rings ill defined and indicated by somewhat darker zones, due to a diminution in the pore distribution. Ripple marks not present.

Minute Anatomy.

Cross Section.

Pores numerous, comparatively evenly distributed; almost always single, rarely in groups of 2-3; usually oval in shape with the greater diameter, radial; variable in size; radial diameter 75-260μ, mean 150μ; tangential diameter 55-170μ, mean 110μ; walls 3-4μ in thickness; number per sq. mm., 16-21; tyloses very prevalent; pores occasionally more or less filled with light coloured granular material which is insoluble in boiling water, alcohol, or chloroform, and does not show any evidence of staining with alkannin. Wood fibres moderately thick walled, often with greater diameter radially directed; average diameter 25μ; walls up to 6μ in thickness; bordered inter-fibre pits readily visible in section. Wood parenchyma diffuse, or to a slight extent vasicentric: often in short tangential rows of 2-6 cells cells up to 40μ in diameter. Rays numerous, conspicuous, with reddish brown granular or amorphous contents which are darkened by iron salts; considerably undulating in contact with vessels; 13-16 per mm. of cross section. Growth rings not well defined and only indicated by reduction in pore number.

Radial Section.

Vessel segments 300-750μ in length; end walls usually oblique; end perforation simple; end projection usually prominent and measuring up to 300μ in length. Vessel-tracheid pits not crowded, border rounded to oval, usually in longitudinal pattern corresponding to the position of the tracheids. Vessel-ray pits very large, semi-bordered, irregularly oval, very distinct from other vascular pitting; inter-vessel pits often elongated, scalariform. Wood fibres 600-1700μ in length, very prominently pitted, the inter-fibre bordered pits in section appearing almost like a row of beads; borders usually very distinct, pit opening

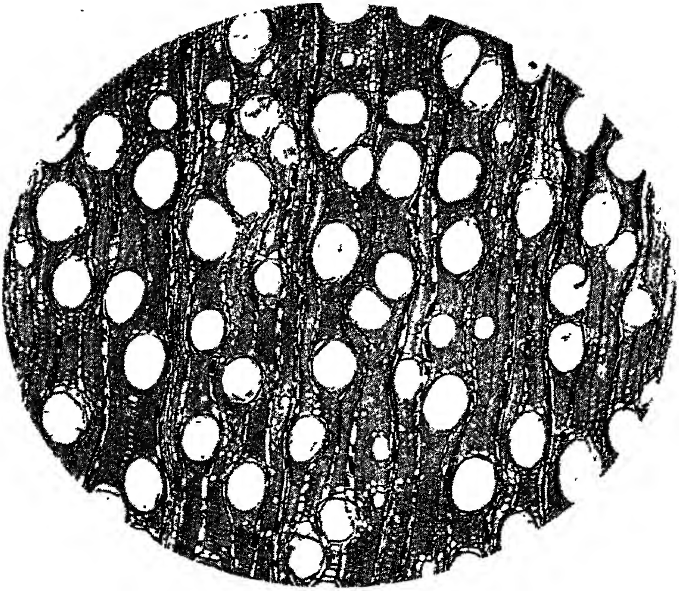
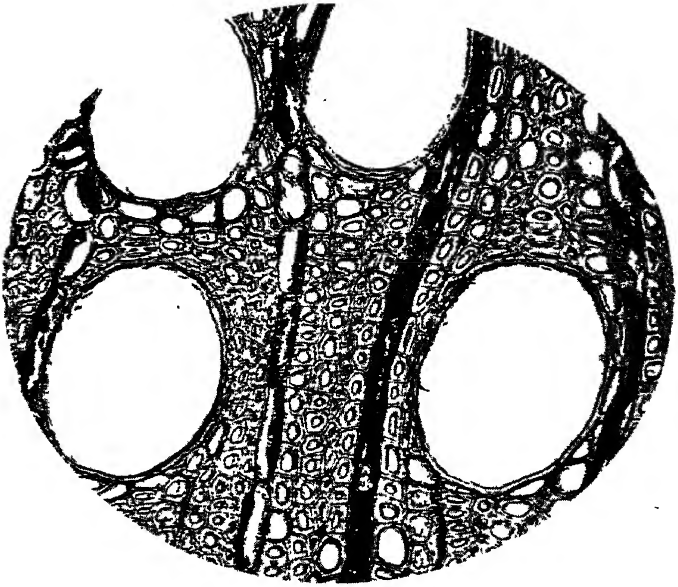


Fig. 1.



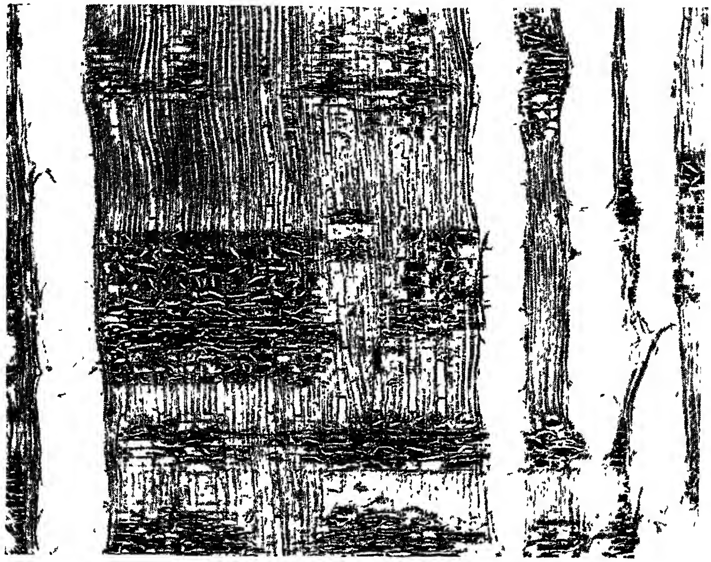


Fig. 3.

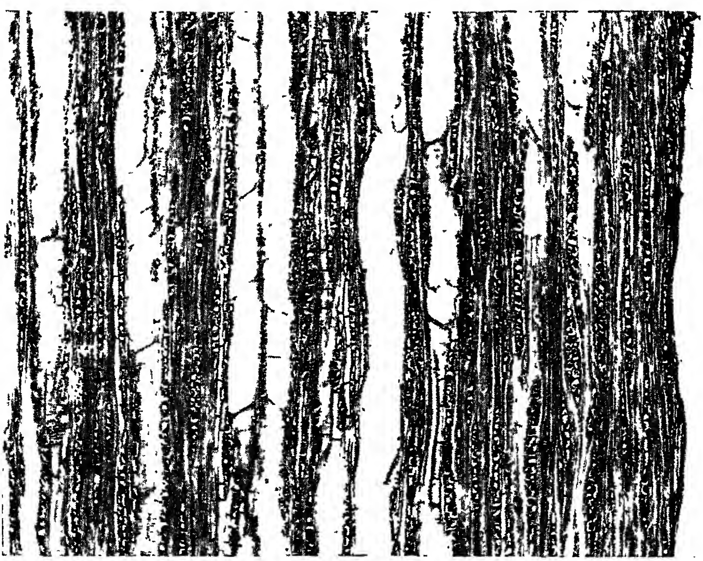


Fig. 4.

oval to slit like; fibres pass through every degree of variation to copiously pitted tracheids; both fibres and tracheids are often very irregular in shape. Wood parenchyma thin walled, in elongated strands, not prominently prosenchymatous; cells almost rectangular, cells occasionally conjugate; pits small, usually rounded, numerous; crystals not observed. Rays strongly heterogeneous, vertical cells 1 to many rows, occasionally nearly the whole ray consists of almost square vertical cells; cells moderately thick walled; inter-cell pitting prominent; ray-tracheid and ray-fibre pits small, number depending on degree of pitting in adjoining mechanical cell; few and slit like or wanting in contact with fibres, more numerous, rounded, adjoining tracheids; ray-parenchyma pits small, rounded, numerous; contents reddish-brown, usually clear and amorphous and almost completely filling cell cavity, but sometimes densely granular; oil globules occur in ray cells and to a lesser extent in wood parenchyma.

Tangential Section.

Wood fibre and tracheid pitting very prominent in section and in surface view. Wood parenchyma usually in 1-4 rows, more prominent than in radial section. Rays very numerous, diffuse, uniseriate or biseriate, rarely triseriate, occasionally branched, or with two biseriate portions connected by uniseriate ray; one to many cells in height, vertical height up to 2100μ.

Aqueous extract pale brown in colour; heavy blue black precipitate with ferric chloride; brown precipitate with potassium bichromate.

Red Satinay can be separated from Turpentine, *S. laurifolia*, by the smaller pores and thicker walled fibres in the latter wood, but probably most easily by the prevalence of uniseriate rays in the Turpentine, whereas in Satinay they are commonly biseriate and even triseriate. Whereas

shavings of Brush Box, *Tristania conferta* smoulder to a light coloured ash, Red Satinay and Turpentine do not smoulder and burn "black." The rays are much more homogeneous, and the fibres and vessels much thicker walled in Brush Box than in Red Satinay.

Mechanical Tests.

A series of mechanical tests was made on material supplied by the Queensland Forest Service. The tests were made in conformity with the standard practice for testing small clear specimens.* Average moisture content, 15.2%.

Static Bending Tests.

Size of specimens 2in. x 2in. x 28in. span centre loading.

	f_1	f	E	W to P.L.	W to M.L.	S at P.L.	S at M.L.	W	M
Max.	13000	18900	2680	3.98	15.79	465	675	56.7	15.8
Min.	7970	11080	1490	1.57	4.21	285	396	48.6	14.3
Mean. (10 tests)	10050	14810	1984	2.83	9.47	359	518	51.7	15.2

f_1 = Fibre stress at proportional limit in lbs. per sq. in.

f = Modulus of rupture in lbs. per sq. in.

E = Modulus of elasticity in 1000 lbs. per sq. in.

W to P.L. = Work to proportional limit in in. lbs. per cu. in.

W to M.L. = Work to maximum load in in. lbs. per cu. in.

S at P.L. = Horizontal shear in lbs. per sq. in. at proportional limit.

S at M.L. = Horizontal shear in lbs. per sq. in. at maximum load.

* Project No. 1. Forest Products Research Laboratory, Dept. of Scientific and Industrial Research, London, 1928.

W = Weight per cubic foot in lbs. at time of testing.

M = Moisture percentage at time of testing, calculated on dry weight.

Compression, parallel to grain.

	C_1	C	E
Max.	6500	10070	3,636,000
Min.	3500	6500	1,364,000
Mean (7 tests) ..	4955	7800	2,655,000

C_1 = Compressive stress at proportional limit in lbs. per sq. in.

C = Crushing strength at maximum load in lbs. per sq. in.

E = Modulus of Elasticity in lbs. per sq. in.

Other Tests.

	$C\rho$	Hr.	Ht.	He.	I
Max.	2,450	1,750	1,910	2,150	15
Min.	1,450	1,250	1,210	1,580	4
Mean	1,845	1,480	1,490	1,800	8
(10 tests)	(6 tests)			(12 tests)	

$C\rho$ = compressive stress at proportional limit, perpendicular to the grain, in lbs. per sq. in.

Hr, Ht, He = load required to imbed a ball 0.444in. diameter to half diameter, on radial, tangential and end surfaces respectively. (Hardness.)

I = Energy absorbed in foot lbs., determined by Izod Impact test, half of tests radial and half tangential.

	S.	Cl.	Tr.	Tt.
Max.	2,210	665	1045	450
Min.	1,340	300	265	145
Mean	1,739	400	547	297
	(11 tests)	(10 tests)	(9 tests)	(10 tests)

S = Shearing strength, parallel to grain, in lbs. per sq. in.

Cl = Cleavage strength in lbs. per in. width.

Tr. & Tt. = Tension perpendicular to grain in lbs. per sq. in.; r and t indicate that the place of failure is radial or tangential.

The screw holding properties were determined, using a 14 gauge wood screw, inserted to a depth of one inch in hole drilled $\frac{13}{64}$in. in diameter.

	Scr.	Sct.	Sce.
Max.	1050	1130	910
Min.	880	1040	700
Mean (6 tests)	998	1082	800

Sc = the load in lbs. required to extract the screw by means of a direct pull r, t and e being on a radial, tangential and end surface respectively.

The results of the static bending tests on Red Satinay showed that the wood was inclined to be brittle and to fail in brittle tension without warning, the broken pieces often flying out of the machine. The comparatively low energy absorption indicated by the work to the proportional limit and to the maximum load, also show that the wood is not particularly tough. The mean result of the Izod Impact tests confirms the view that the wood commonly lacks toughness, the mean figure of 8 foot lbs. for the energy of rupture being low, considering the density of the wood. It is of interest to note that the mean result of 72 impact tests made on Australian grown *Pinus insignis* was 16.7 foot lbs., with a mean density of only 32.8 lbs. per cubic foot. The modulus of elasticity is high and shows that the wood is able to carry considerable loads with little deflection.

Compression, hardness, shear and tension figures are apparently normal, although the tension results in a tan-

gential plan are low. Insufficient figures are available for other Australian timbers to allow of a general comparison being made.

Fire Resistance.

Tests were made by the writer to determine the relative resistance to burning of Red Satinay in comparison with Turpentine, *S. laurifolia*. The apparatus used was designed by Mr. R. Cherry, who carried out a number of experiments on the fire resistance of Australian and other timbers.* The material used (Red Satinay and Turpentine) was supplied by the Queensland Forest Service.

The method is to use a small simply supported beam, loaded centrally by means of a spring; a small gas flame is allowed to impinge on the lower surface of the beam, and the time taken for the beam to break is measured.

		b	d	t
Red Satinay	Mean 6 tests	0.482	0.475	4 min. 38 secs.
Turpentine	Mean 6 tests	0.484	0.489	9 min. 52 secs.

b and d = breadth and depth of test pieces in inches.†

Although inferior to Turpentine, the wood is nevertheless very fire resistant, an extremely useful property in a wood used for building purposes and interior fittings.

In conclusion, I am indebted to Mr. F. B. Shambler, of the Museum Staff, for the preparation of the test specimens and his assistance during the making of the tests, and to the Mechanical Engineering Department, Sydney Technical College, and to the Australasian Scale Co., Sydney, for the use of the necessary machines.

* Cherry, G. R. Comparative Combustibility of Timbers. Jour. of the Insurance Institute of New South Wales, 1903.

† The results of these tests are published in full by Swain, l.c.

EXPLANATION OF PLATES.

Plate X.

Syncarpia Hillii, Fig. 1. Transverse sections of wood showing diffuse porous structure. The pores are usually single. The crowded undulating rays are prominent.

Syncarpia Hillii, Fig. 2. Transverse section, more highly magnified, showing distribution of wood parenchyma. The inter-fibre bordered pits are visible in section.

Plate XI.

Syncarpia Hillii, Fig. 3. Radial longitudinal section showing heterogeneous rays. The bordered pits of the wood fibres are very distinct. Owing to the undulation of the rays it is difficult to obtain a longitudinal section showing the ray over more than a short distance. The wood perenchyma is commonly in isolated strands.

Syncarpia Hillii, Fig. 4. Tangential longitudinal section showing the numerous rays which are chiefly uniseriate.

ADDENDA.

Magnification Plate X., Fig. 1, x 36.
" " X., Fig. 2, x 185.
" Plate XI., Fig. 3, x 40.
" " XI., Fig. 4, x 40.

In the fifth line of Explanation of Plate XI., Fig. 3, for "perenchyma" read "parenchyma."

ON SOME INTERESTING GEOLOGICAL FAULTS IN THE VICINITY OF BRANXTON, N.S.W.

By

G. D. Osborne, D.Sc., and H. G. Raggatt, B.Sc.

(With three text figures.)

(Read before the Royal Society of New South Wales, Dec. 5, 1929.)

Introduction.

Branxton Railway Station is situated on the Main Northern Railway Line 34 miles 37 chains from Newcastle, or 134 miles from Sydney, the latter distance being indicated by the mile-post which occurs just near the station.

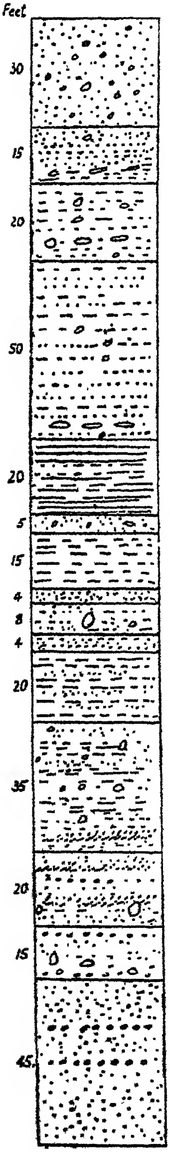
To the west of the station, beginning at a mileage of 134-20* and continuing to a mileage 134-65, is a large railway cutting, trending approximately east and west, which exposes sediments belonging to the Branxton Stage of the Upper Marine Series (Permo-Carboniferous or Permian System). Beyond the cutting, to the west, is Black Creek, at mileage 134-70, and the section traversed between this stream and Branxton Station is across portion of the western side of the Lochinvar anticline or dome.

In the cutting a number of interesting geological structures are revealed, chief amongst which is a series of faults, mainly of the overthrust type. In view of the fact that the Branxton district is frequently visited by geological excursion parties from the University of Sydney and other institutions, and particularly, since on such occasions a detailed examination of the cutting in question is generally

* In giving distances, the plan adopted in this paper is to state the number of miles and chains from Sydney, e.g., 134-20 means 134 miles 20 chains.

Section of Branxton Stage between Black Ck. and Branxton Stn.

(Descending Stratigraphically).



... Sandstone with pebbles and erratics not exceeding 6 inches in diameter.

... Alternate sandstone and sandy shale, the former predominant at top. Pebbles and erratics up to 1ft. diam. Fossil wood. *Martiniopsis* and *Fenestellidæ* abundant. Junction with underlying beds somewhat disconformable.

... Thinly - bedded shale with abundant *Fenestellidæ* and sporadic erratics, the larger ones measuring about 4½ft. x 2½ft.. vertical section. Three calcareous concretions.

... Sandstone and shale in alternating beds from 2 to 4 feet thick. Fossiliferous calcareous lenses, four feet from base. A few pebbles and erratics occur.

... Blue, finely laminated sandy shale, many of the laminæ being richly fossiliferous.

Fenestella Shales.

... Fine-grained argillaceous s. stone with sporadic pebbles.

... Shale.

.. Lenticular sandstone bed.

... Sandy shale. Granite erratic exceeding 30 cub.ft. in volume.

... Friable fine-grained argillaceous sandstone.

... Mainly shale with some beds of argillaceous sandstone.

... Sandstone with thin argillaceous bands. Pebbles and erratics of variable size, current bedding near base.

... Current-bedded sandstone with pebbly bands. One erratic present measures 2ft. x 1½ft in vertical section.

... Mainly fine-grained conglomerate with a few erratics.

... Chiefly fine-grained compact sandstone with some thin pebbly bands.

Total thickness, 306ft.

Fig. 1.

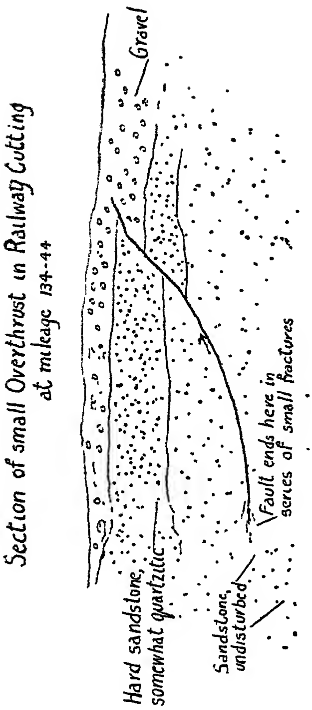

Section of small Overthrust in Railway Cutting
at mileage 134-44
Gravel
Hard sandstone, somewhat quartzitic
Sandstone, undisturbed
Fault ends here in series of small fractures

Fig. 2.

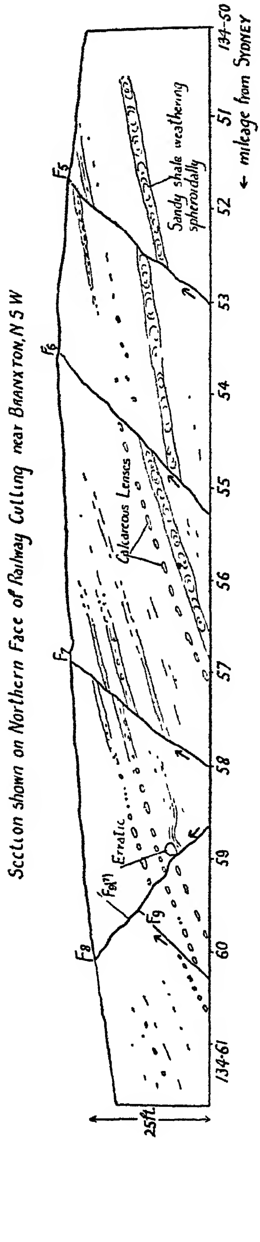

Section shown on Northern Face of Railway Cutting near BRANXTON, N S W
F5
F6
F7
F8
F9
F9(?)
Erratic
Calcareous Lenses
Sandy shale weathering spheroidally
134-50
51
52
53
54
55
56
57
58
59
60
134-61
← mileage from SYDNEY
25ft.

Fig. 3

made, it has been thought desirable to record the stratigraphy and to describe the faults, indicating their significance in relation to the tectonic geology of the district.

Stratigraphical Notes.

The rocks exposed in the railway cutting between Branxton Station and Black Creek bridge show a gradual change from east to west, i.e., ascending stratigraphically, from beds dominantly sandy to finely laminated and richly fossiliferous shales.

A. B. Walkom[1] in dealing with the stratigraphy of the Maitland-Branxton district referred to the general lithological features and listed the fossils occurring within the Branxton Stage.

A detailed section of the sediments in the cutting has recently been measured and is given in text-fig. 1. It may be mentioned here that the erratic figured by Professor David[2] in 1907, and now obscured by soil, belongs to the unit which occurs third from the top of the section given in text-fig. 1.

The Fenestella Beds, of which a splendid section is exposed in the cutting, are a very important horizon from an economic viewpoint, inasmuch as they occur approximately 1550 feet above the top of the Greta Coal Measures. The lower 115 feet consists mainly of sandstone, which is the same as that indicated as a massive sandstone bed on Sir Edgeworth David's Geological Map of the Hunter River Coalfield in portion 139, Parish of Branxton, County of Northumberland. This bed forms wall-like outcrops for two or three miles south of the railway cutting, and at first sight might easily be mistaken for the Muree Beds.

Details of the Faults.

There are two portions of the cutting where groups of faults and related structures occur. These are respectively

within the distance 134-40 to 134-44, and in the interval between 134-50 and 134-60.

The latter place is the more important, and the faults occurring thereabouts are illustrated in text-fig. 3. At the former place the following structures are present:—

(i.) At mileage 134-40 there is an overthrust fault, F_1, which dips N. 62° at 37° (approx.). The throw is approximately 1½ ft. and the heave 2 ft.

(ii.) At mileage 134-44 there is a very instructive overthrust, F_2, a diagram of which is given in text-fig. 2. This is seen on the north side of the cutting, where a hard, somewhat silicified sandstone has been fractured. The general dip of the fault is in the direction S. 65° W. and in the upper part of the structure there is a small displacement. As one follows the fault surface down it is seen to decrease in dip and to curve towards the horizontal, eventually dying out in a zone of minor fractures and passing into solid rock, whose elastic strength has taken up the strain to which the mass was subjected when the fault developed and caused displacement elsewhere in the sandstone block.

This fault is a splendid example, on a small scale, of the nature of many thrusts, and one can interpret from the section the manner in which a thrust-fault dies out and passes into undisturbed rock-material. The curving of the fault-surface (see text-fig. 2) is very characteristic, and by analogy, it may be inferred that such a curving, with concavity upwards, takes place in many of the larger thrusts. This feature was suggested by one of us[3] for the Great Boundary Fault or Hunter Overthrust, which occurs some distance to the north-east.

(iii.) At mileage 134-44½ there are two steep normal faults, F_3 and F_4, which are seen best on the south side

of the cutting. These cut through the sandstone and dip at a high angle to the south-south-west. The throw in each case is very small.

The Main Group of Thrusts.

The relative positions of the faults in this group are shown in text-fig. 3, which as stated, shows the section exposed upon the north face of the cutting. Some of the faults are fairly well-exposed on the southern face, but a complete section is not obtainable on that side. The details revealed there, however, have been used to correlate structures across the cutting, and thus arrive at fairly reliable results for such items as the throw, strike, etc., of the faults. These are summarised in the table below:—

Fault	Dip		Throw (approx.)	Heave (approx.)
	Direction	Amount.		
1	N. 62° E.	37°	$1\frac{1}{2}$ ft.	2 ft.
2	S. 65° W.	See text	See	text
3	S.S.W.	75°—80°	1 ft.	—
4	S.S.W.	75°—80°	8 ins.	—
5	S. 50° W.	42°	4 ft.	3 ft.
6	S. 55° W.	44°	1 ft.	2 ft.
7	S. 34° W.	47°	$2\frac{1}{2}$ ft.	3 ft.
8	N. 25° E.–N. 40° E. (?)	(See	note	below)
9	S. 50° W.	37°	9 ins.	10 ins.

NOTE.—The section of Fault No. 8 on the northern face of the cutting gives an apparent dip of 12° for the structure, but the section on the south side indicates that the true dip of the fault is considerably greater, although there is not enough information available to determine the strike or the value of the true dip.

General Discussion.

It will be seen that the faults agree reasonably closely in strike-direction. This is found to vary from about north-west to north-north-west, the chief exception being

that of F_8, about which there is some doubt. Now it is found on examining the general folded structure in the Branxton area that there is a gradual change in dip from the neighbourhood of Black Creek to near Branxton Station. At the former locality the dip is W. 20° N. at 12°, while at the latter it is N. 25° E. at 47°. The first-mentioned is the general dip of the beds on the western limb of the Lochinvar anticline in this locality. The latter dip is undoubtedly due to the influence of the Greta Fault, which passes from near the railway station in a north-westerly direction into the sharp fold defined by the Muree Beds north-west of Branxton.

The general strike of the faults is more or less parallel to that of the Greta Fault and of the Hunter Overthrust and this fact, taken in conjunction with a knowledge of the tectonic history of the area, suggests that all these faults were produced by the same general set of earth-movements.

The probable genetic relation between the Greta Fault and the Great Boundary Fault or Hunter Overthrust has been suggested by one of us (H.G.R.)[3a], and the thrusts described here, although differing in character from the Greta Fault, represent, we believe, shear-planes developed about the same time as this fault, and are not due to tensional forces.

The authors have shown[3 & 4], in dealing with various phases of the structural geology of the Hunter Valley, that at least two orogenic movements affected the Branxton and surrounding districts, one of these producing meridional folds and faults and the other being characterised by the formation of the Hunter Overthrust, which developed as a result of a general thrust from the north-east towards the south-west. At the time of this second diastrophism the Lochinvar anticline existed, and the Upper Marine Beds at

Branxton possessed the general dip shown at the present time. It is also almost certain that, at the same time, no great mass of rock overlay the present Black Creek-Branxton section, and thus the conditions existing were those of strong sub-horizontal compression, with least compression in a vertical direction.

Under these conditions it has been shown experimentally (see[5]) that shear-planes will develop in homogeneous brittle rock-masses. These fractures will be in systems which intersect at varying angles according to the nature of the material. The intersecting planes are so arranged that the direction of thrusting bisects the acute angle between them.

Now in the present case it is seen that two sets of fractures are represented, as the two normal faults, F_3 and F_4, are probably unrelated in origin to the thrusts. One system of fractures has a general dip to the south-west or west-south-west at angles varying from 37° to 47°. The other set embraces one fault, F_8, whose true dip is unobtainable and another, F_1, which dips to the east-north-east at 37°. This means that the acute angle between the two systems varies from 74°-84°. In the ideal case, with brittle material like sandstone, the angle is about 60°. In the present instance, however, it should be noted that the beds consist of alternating shaly and sandy bands of varying resistance, and that these beds were not lying horizontal at the time of compression. The existence of inclined bedding-planes, acting as planes of weakness, would tend to produce angular relationships between the fracture-systems which would differ from those obtained in the ideal case.

The occurrence of the wedge or prism of rock formed by the intersection of the faults, F_7 and F_8, and the presence of the border-thrusts, F_5 and F_6, remind one of the results obtained by R. T. Chamberlain and Richards[6, 7] from experi-

ments dealing with the effects of compression upon certain materials. In these experiments the original masses were wedge-shaped, and compression produced by clamping both sides of the wedge caused the development of overthrusts in the central portion of the masses, and the squeezing-up of a central wedge, which was flanked by parallel border-thrusts. Under somewhat similar conditions wedge-faulting was also produced in loose sand. One of the chief features of these experiments is that little vertical compression exists, the conditions being almost equivalent to tensional stress in an upward direction. We believe that the wedge in the Branxton section, with its bordering thrusts, is an illustration, on a small scale, of the production of earth-wedges, as conceived by Chamberlain.

A further point of interest about the Branxton faults is that they emphasise the fact, first demonstrated by Cadell[8] in his classical experiments, that thrusts do not necessarily result from upturned folds. This feature is also shown on a grand scale by the Hunter Overthrust.

The authors are grateful to Professor L. A. Cotton for helpful discussion during the preparation of this note.

(One of the authors [H.G.R.] acknowledges the permission of the Minister of Mines to collaborate in this paper.)

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NOTE ON AN OCCURRENCE OF QUARTZITE CONTAINING COMMON OPAL AND CHALCEDONY AT TALLONG, N.S.W.

By L. L. Waterhouse, B.E.,
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and
W. R. Browne, D.Sc.,
Assistant-Professor of Geology, University of Sydney.

(With Plate XII and one Text-figure.)

(Read before the Royal Society of New South Wales, Dec. 4, 1929.)

Introduction.

The country in the neighbourhood of Tallong contains many features of interest to the geologist. Among other things there is exposed in the bank of the gorge of the River Shoalhaven an extraordinarily fine example, of text-book clearness, of a right-angled unconformity, Ordovician schists and phyllites being overlain by practically horizontal Permo-Carboniferous breccias, conglomerates and massive sandstones. These in their turn have been covered by a flow of Tertiary basalt, which, along the edge of the left bank of the river near Badgery's Lookdown, has been eroded away in places, revealing a layer of hard glassy quartzitic rock. These relations are shown on the sketch-section herewith. Attention was first called to this, as to the other geological features of this important area, by Dr. W. G. Woolnough.[1]

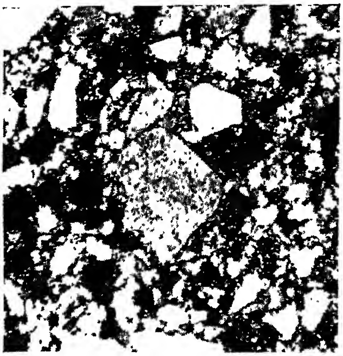


Fig. 1.

Fig. 2.

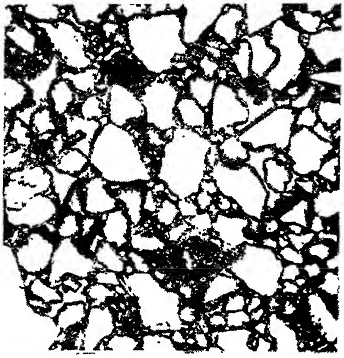


Fig. 3.

Fig. 4.

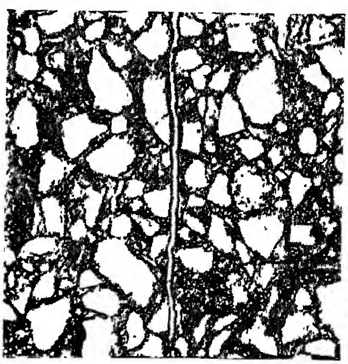
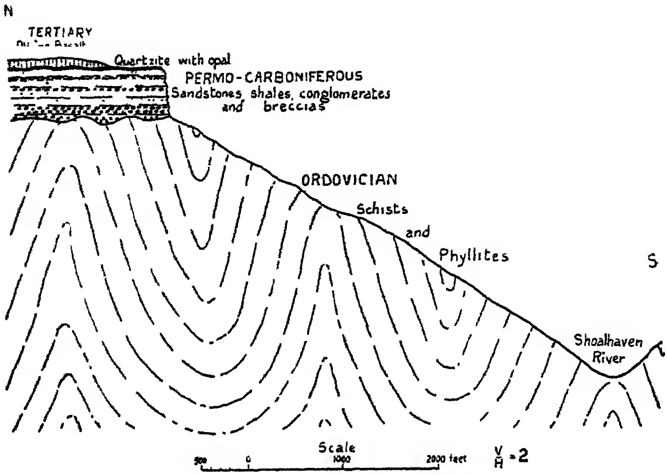


Fig. 5.

[*H. Gordon Gooch*



Sketch-Section near Badgery's Lookout, Tallong, N.S.W.

The quartzite, which is only three or four feet in thickness, has usually been regarded as silicified Permo-Carboniferous sandstone, where impregnation by silica occurred in connexion with the Tertiary basaltic outpourings. A few years ago, however, the suggestion was made to us by Miss Ida A. Brown, B.Sc., that the quartzite might really represent an original Tertiary terrestial sand, she having investigated very similar rocks near Ulladulla and elsewhere on the South Coast of New South Wales, whose silicification was undoubtedly related to Tertiary basalt-flows[2]; these quartzites were found to enclose remains of petrified wood definitely determined to be of Tertiary age. As some specimens of common opal had been found among this South Coast quartzite, a search was made last year, during the course of a geological excursion by University students, among the quartzites near Badgery's Lookdown, with the result that the presence of opal and chalcedony in these rocks was definitely established, a fact which it has seemed to us desirable to place on record.

Petrographical.

The unaltered sandstone is an ordinary fine-grained type. Under the microscope the quartz-grains, variable in size but seldom more than 1 mm. in diameter, are notably angular. An occasional grain is composite in character, as if derived from a pre-existing quartz-vein, and the tiny inclusions so characteristic of plutonic quartz are sometimes to be seen.

Quartz is the predominant granular mineral, but in addition there are flakes of muscovite and bleached biotite, and a few grains of brown tourmaline. There are also grains of orthoclase felspar, but generally so altered to sericite and kaolin that any estimate of their abundance is impossible.

The cementing material has been largely converted into sericite, and to indeterminate cryptocrystalline material. A few patches of fibrous, colourless chlorite (?) appear in the paste. It appears evident that the sandstone has been derived principally from an acid granite, and that a certain amount of recrystallization has occurred during the process of cementation.

The quartzites show considerable variation among themselves in texture and colour. All are exceedingly hard and dense, but while some are coarse and uneven in grain, evidently representing silicified grits and pebbly grits, others are fine-grained like normal quartzites. Others again are exceedingly fine-grained, resembling cherts and jaspers. The colour may be white, grey, red, brown, reddish-brown or black. In the very fine jasperoid red and brown types silicified woody structures have been found, and in them, too, are frequent thin veinlets and irregular white patches of opaline and chalcedonic character. The lustre of the rocks is more or less vitreous, with a suggestion of oily or greasy

lustre in some of the very fine-grained types. They are all very hard when fresh, and some of them remain so on exposure to the weather, but others containing kaolin soften and lose their glassy lustre. A sub-conchoidal fracture is often noticeable. The quartzites resemble in their general characters much of the so-called "grey billy" of the dry interior parts of the State.

The field-relations of the different types are difficult to determine; no regular gradations are evident, but just an apparently haphazard passage from one to another. Possibly an exhaustive investigation would reveal some method in the distribution of types, but it seems not unlikely that the variations are the result partly of the ill-assorted nature of the original material and partly of the unequal incidence of solutions which may have carried iron as well as silica.

Microscopic examination shows that there are several interesting features connected with the cementation of the original sand-grains. The clastic grains of the rock are in all cases practically entirely of quartz, with odd granules of tourmaline, zircon and sphene, some felspar and a few very tiny shreds of muscovite, but these last two minerals are much scarcer than in the parent sandstone. The quartz-grains are markedly angular, and the prevalence of concave sides to them is very striking. They give the impression of having been produced by the disintegration of a quartz-rock through the flaking-off of the grains. In regard to the original clastic material the quartzites are very variable in grainsize, and there is but little evidence of sorting.

In one type, perhaps the most common, the grey-coloured rock consists mainly of an uneven aggregate of clastic quartz-grains set in a matrix which is of microcrystalline

quartz, the granules having sutured junctions and being evidently due to deposition from solution (Plate XII, Fig. 1). How far this deposition has occurred as enlargement of existing tiny clastic quartz-grains it is impossible to say, but there are in places distinct indications of outgrowths to the larger grains. Some of the rocks of this type contain occasional little interstitial fillings of almost cryptocrystalline quartz, very similar to that which is found replacing felspars and other minerals in silicified igneous rocks. The grey colour of the rock is due to the kaolin which is scattered through the matrix.

This type is practically indistinguishable microscopically from the Ulladulla quartzite.

We turn now to those types in which the interstitial silica is in the form of opal with or without chalcedony. In some of these the opal is apparently just an exceedingly subordinate cementing material to the close-packed, tiny, clastic granules which fill in the spaces between the larger grains, in others the grains are separated by kaolin, which is intimately associated with opal, as though it had been thoroughly soaked by the siliceous solutions (Plate XII, Fig. 2); in these rocks the kaolin-opal matrix may make up roughly 30% of the entire rock. In the red and brown quartzites the place of kaolin is taken in part by earthy haematite and limonite. The kaolin is doubtless an original or pre-basalt cement, but it is not quite clear whether the same statement applies to the iron-oxides; there seems a probability that they may have been introduced subsequently, but in any case they were deposited before the opal, and some specimens have been collected whose appearance rather suggests that the iron-oxide was removed altogether in places and replaced by opal.

Yet another type of matrix is found in the quartzites. In this the opal forms an exceedingly narrow fringe or

investment to the clastic quartz-grains, and the tiny angular interspaces are filled with fibrous-radial chalcedony which is sharply bounded against the opal (Plate XII, Fig. 3). The quartz-grains are never in contact, so that apparently either the opal and chalcedony have replaced the former cement, or else, as seems more probable, the siliceous solutions percolated through an incoherent mass of sand, with much pore-space, first depositing a film of opal on the grains and afterwards filling the remaining space with chalcedony.

Apart from functioning as a cement the opal and chalcedony appear with or without haematite as fillings to narrow irregular cracks through the quartzite. In these veinlets, which sometimes cut right through quartz-grains, and were therefore formed after cementation, the opal occurs as a lining to the walls, the middle space being filled with fibrous chalcedony (Plate XII, Figs. 4 and 5). These veinlets are found even in quartzites which are free from opal as a cement, but they are perhaps particularly characteristic of the very fine red jasperoid rocks. No quartz-filled veinlets have been found, though it appeared to us that in some places the central filling of a veinlet was of finely-granular quartz.

The woody structures referred to above are preserved in opal and cryptocrystalline quartz plentifully stained with iron oxides, and they also are intersected by opal-chalcedony veinlets.

It should be mentioned that the opal is easily recognizable by its very low refractive index and by its general isotropism; only rarely are there indications of a very feeble birefringence. The chalcedony has fibrous or fibrous-radial structure, a low birefringence, a refraction slightly below that of Canada Balsam, and a negative elongation of the fibres.

The absence of any signs of precious opal from our collection is worthy of remark. This may be because it does not occur, or because it was not searched for sufficiently. However, local inquiry failed to elicit any evidence that precious opal had been found at Tallong, and in our opinion there is no compelling reason why the precious type should be found with the common opal.

Original Condition of the Quartzites.

There is nothing in the field-occurrence of the quartzites to indicate definitely that they have not resulted from impregnation of the Permo-Carboniferous sandstones by siliceous waters. Sharp junctions with the underlying unaltered sandstones are not seen, but one can readily imagine that there is a gradual though fairly rapid passage from quartzite down into sandstone. A microscopic examination of the quartzite, however, reveals a very close resemblance to the Ulladulla quartzite, as well as to the silicified Tertiary sands of Mt. Macedon, Victoria, described by Skeats and Summers.[3] In addition to this the detrital grains of the quartzite, though entirely similar in kind, differ in shape and arrangement from those of the unaltered Permo-Carboniferous sandstone, and the impression is gained that the latter has in Tertiary times under subaërial weathering suffered disintegration resulting in the accumulation of a layer of angular quartz-sand as a kind of sedentary or perhaps alluvial soil. Such a mantle of sand is to be seen about Tallong itself, and particularly at the neighbouring town of Wingello, produced by weathering of sandstones either during the Tertiary peneplanation or during the present cycle of erosion.

Colour is lent to the possibility of a Tertiary mantle of sand by the consideration that in a compact sandstone with no very considerable pore-space the heated siliceous waters

would penetrate with comparative slowness and affect but a thin layer, whereas percolation through a loose, uncompacted sand would be easy and rapid, and would be likely to extend down through the full thickness of the disintegrated material; the effects would then die out gradually in the partially decomposed but still comparatively solid rock beneath. This might account for the existing thickness of quartzite, and for the absence of a sharp plane of division between it and the unaltered sandstone.

In certain jasperoid phases of the quartzite abundant well-preserved silicified woody structures were detected with the microscope, but it has not been possible to gain from them sufficient information to settle the question of the probable geological age of the plant-material.

On the whole we consider that there is quite a strong probability that Miss Brown's suggestion is correct, that the quartzite is really a cemented Tertiary sand.

Causes of the Silicification.

Quartzites petrologically similar to those being dealt with are found in this State under a variety of circumstances and due to a variety of causes. First of all there are the rocks, such as the Upper Devonian quartzites, which are apparently due to the transformation of rather siliceous sandstones under conditions of regional and sometimes of contact metamorphism, the Devonian rocks having been not merely folded but invaded by granite in places. Such rocks are found among our older and middle Palaeozoic sedimentary formations.

Secondly, we may recognise those quartzites which occur extensively as cappings to hills and ridges in the drier interior parts of Australia, as, for instance, at White Cliffs in this State.[4,5,6] These are level-bedded, often overlie Cretaceous marine sediments, and are usually attributed to

cementation of outcropping rocks or sands through the exudation of silica in solution from the rocks beneath the surface, either during the present physiographic cycle or during an earlier one of Tertiary age. In a third group may be placed those rocks, originally river-sands and gravels mainly, whose cementation has been very evidently connected in some way with the outpouring of Tertiary basalt, inasmuch as they are either actually overlain by basalt-flows or else are restricted to areas from which the lava has been eroded.[2,7,7a]

To the quartzites and silicified conglomerates belonging to the last two groups, the term "grey billy" is often applied by miners, and to some extent the name is used descriptively by geologists, but its undeniable convenience and usefulness are somewhat marred by the fact that the colour of the rocks is by no means constant, buff, red and brown tones being common.

It is very clear that the Tallong quartzites belong to the third of the groups just mentioned. They appear not as a widespread covering to the sandstone country, but purely as a local occurrence, and their close association with the basalt puts their relation to it beyond reasonable doubt.

Source of Silica and Causes of Deposition.

The question next arises as to the exact source of the silica by whose deposition the change from sand to quartzite was effected. Clearly it must either have been introduced from without, that is, from volcanic sources, or else have been already present in the sand at the time of the volcanic eruptions, either in the form of quartz-grains or else in solution in waters mechanically contained within the layer of sand.

The generally-received explanation of the formation of contact-quartzites of this kind is that the sediments—sands,

gravels or sandstones—became saturated, during the period of volcanic activity, with highly-heated waters of volcanic derivation containing silica which was subsequently deposited, with decreasing temperatures, as quartz, opal or chalcedony.[7,7a] Under this explanation the cementing silica is entirely of foreign origin. But it has also been suggested that the heat produced by the overlying lava would quicken the solvent power of the water already contained in the pore-spaces of the sediment and cause it to attack the grains and take silica and other substances into solution.[2] According to analyses quoted by F. W. Clarke[8] it would appear that river-waters may contain appreciable proportions of silica and also probably of alkali carbonates and silicates, doubtless derived largely from the decomposition of silicate minerals. If the sediments before being overlain by the lava contained such waters, then not merely would there be some silica available in solution, but on the heating-up of the waters quartz and other minerals of the sediments would be attacked by the alkali solutions and the silica content of the waters would be correspondingly increased.

There appears to be a third possibility. There is much evidence in both lava-flows and intrusions that the residual magmatic waters of certain basic magmas may contain alkali carbonates and silicates in solution. These soaking through porous sediments at high temperatures might readily attack both quartz and felspar, resulting in the taking of silica into solution.

The last two processes would of course involve corrosion of the attacked quartz-grains, and as a matter of fact in some of our thin sections of the quartzites there are what we consider to be evidences of such corrosion, particularly marked in those rocks which contain much opal in the matrix (Plate XII, Fig. 2).

The problem, however, is not merely one of the method by which the silica was taken into solution, but also of the means by which deposition was accomplished. Where the silica was in solution at high temperature the obvious result of cooling would be precipitation in the form of quartz or some other silica-mineral, as has been the case in quartz-veins, and since in the present instance the solutions, whether original or introduced through volcanic agencies, must have been at some time highly heated, falling temperature may be regarded as a possible cause of deposition.

The observed association of quartz and chalcedony in large mineral-veins has been attributed to the differential cooling of hot siliceous waters, quartz having separated at higher and chalcedony at lower temperatures.[9]

It is also on record[10] that the hot waters issuing from Iceland geysers contain alkaline silicates in solution, and that on exposure to the air these are decomposed with the formation of silica and alkali carbonates. Doubtless falling temperature is an important factor in the reaction.

Clarke[11] has brought together much information in regard to the experimental work on the precipitation of various forms of silica, which may have some bearing on the present problem. For instance, it has been shown that quartz taken into solution by alkali silicates at high temperatures is reprecipitated when the temperature is lowered. Such quartz might form extensions of original clastic grains or else appear as a cement, converting incoherent sands into quartzites.

Further, it has been demonstrated that the heating of a solution of colloidal silica brings about the formation of quartz; in the presence of carbonic acid the same result is obtained. It would appear, therefore, that if a sediment contained water comparable with river-water in composi-

tion, then deposition of quartz might take place as a result of mere heating through contact with overlying lava.

The recent experimental work of Moore and Maynard[12] has shown that colloidal silica may be precipitated from a sufficiently concentrated solution by sodium chloride, and to a smaller extent by calcium and magnesium bicarbonates. There is little possibility that any of these substances was present in the sands at Tallong.

It is evident, then, that there are many ways in which silica could have been made available, and deposited directly or indirectly through the influence of volcanic eruptions, and it is possible that more than one process may have been operative.

On the whole, however, having regard to the quantity of silica involved in the cementation of the sand, and to other considerations, we are rather inclined to the view that the bulk of the silica was added to the sands from volcanic sources, and that falling temperature was the main factor in its precipitation.

Mineral-Forms and the Order of Their Deposition.

The evidence of the rocks shows that the silica was deposited in three forms, and in the order: quartz, opal, chalcedony. It is true that a little quartz was detected in the middle portion of one of the veinlets, but we could not be quite certain that this was not a quartz-grain isolated in the veinlet.

We have been unable in the literature at our disposal to find any precise data as to the conditions determining which of these three forms of silica shall be deposited, but presumably the order is to some extent one of decreasing temperature.

It is rather contrary to expectation that chalcedony succeeds opal in the order of deposition: one would hardly

have anticipated that the hydrous amorphous opal would come between the anhydrous and crystalline quartz and the chalcedony; nevertheless the evidence on this point is very clear, the opal being always interposed between quartz and chalcedony in the interstices and the veinlets.

We find nothing to support the view that chalcedony is a mixture of crystalline and amorphous silica; on the contrary its individuality as a separate mineral is very pronounced. Nor is there any support for Dr. Rastall's suggestion[13] that chalcedony represents the crystallization of an original colloidal and amorphous opal. In the quartzites the two minerals are in the closest association, but the boundaries between them are always sharp and clearly defined, with no sign of a transition from one to the other, and no suggestion of a derivative relation.

Similar Occurrences in the State.

Although there are in this State many known occurrences of sand or sandstone converted into quartzite by Tertiary lava-flows, from none of them, so far as we know, has opal been recorded. A few occurrences of common opal there are which may be attributed to contact-action of basalt, but they are not quite analogous to that at Tallong. Jensen[14] mentions veins of opal ramifying through volcanic tuff in the Warrumbungle Mountains; Skeats [15] has described masses of black opal apparently due to the wholesale opalization of earth between two basalt-flows at Tweed Heads; and Morrison[16] in his report on the Tintenbar opal-field refers to a siliceous earth which has been opalized through the influence of an overlying basalt-flow. Silicification of river-alluvium in deep leads has been a frequent occurrence, and occasionally opalized wood has been discovered in such circumstances, and there has been silicification of diatomaceous earth with the production of a kind of

highly vitreous siliceous sinter, probably due to overlying lava-flows; but the only other example of common opal associated with contact-quartzite that we have seen is one shown us by Miss Ida Brown, which was found in the neighbourhood of Moruya, whence there has also been collected a specimen of opalized wood, presented to the University Geological Museum by Mr. W. Flood. Very probably the contact-quartzites of New England and other basaltic areas have never been specially examined for common opal, which might be found if search was made.

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Explanation of Plate.

Plate XII.

Microphotographs.

Fig. 1.—A typical quartzite without opal cement. The clastic quartz-grains are set in a matrix of microcrystalline quartz, the granules having sutured junctions. Abundant tiny inclusions are present in the central quartz-grain. Crossed nicols. x 29.

Fig. 2.—Quartzite with kaolin-opal matrix. Some of the larger quartz-grains such as those at the bottom and the upper left-hand corner of the figure show numerous microscopic inclusions with linear arrangement. Some quartz-grains show corrosion. Ordinary light. x 29.

Fig. 3.—Quartzite with opal cement. The clastic quartz-grains are invested by opal. Part of the opal cement is stained with haematite. It is noteworthy that the quartz-grains are never in contact. The colourless interstitial material is chalcedony. Ordinary light. x 25.

Fig. 4.—Quartzite with quartz cement intersected by veinlet of opal and chalcedony. The veinlet cuts across several quartz grains and encloses quartz fragments. Crossed nicols. x 29.

Fig. 5.—Quartzite with cement composed mainly of opal, traversed by an opal-chalcedony veinlet. The central clear filling of the veinlet is chalcedony, the walls being coated with opal. The dark-coloured matrix in the lower left-hand corner is stained with haematite. Ordinary light. x 29.

STUDIES ON THE HYDROLYSIS OF CELLULOSE. Part I.

By Miss J. Chalmers and J. C. Earl, D.Sc., Ph.D.

(*Read before the Royal Society of New South Wales Dec. 4, 1929.*)

There are a number of methods available for the quantitative hydrolysis of cellulose to glucose, and by the use of some of these, various intermediate products have been obtained and examined. The study of these intermediate products furnishes an important avenue of approach to a knowledge of the structure of cellulose itself, and for this reason the development of further methods of controlled degradation of cellulose is desirable.

The action of methyl alcohol containing hydrogen chloride on cellulose triacetate was employed by Irvine and Hirst (J. Chem. Soc. 1922, 121, 1585) in their quantitative degradation of cellulose. This method has been used repeatedly for the breakdown of many other polysaccharides and their derivatives, and has proved a very useful aid to the study of the structure of such substances. In the particular case of cellulose triacetate the employment of only a small percentage of hydrogen chloride and digestion in a sealed tube at temperatures above 100° C. are recommended as the best conditions under which to apply the reagent.

Various other sets of conditions were explored by Irvine and Hirst, among them being the action of boiling methyl alcohol containing 1 to 2 per cent. of hydrogen chloride at atmospheric pressure. In this case no formation of methyl glucoside was observed after boiling for 24 hours. In spite of this observation, further experiments have now been made with a somewhat greater proportion of hydrogen

chloride, namely, 5 per cent., and it has been established that cellulose triacetate is progressively attacked and also that methyl glucoside is formed. The progressive attack was followed in several series of experiments, one of which is quoted here (Table I). In each case 1 gram of the triacetate was taken and boiled for the specified time with 50 cc. of methyl alcohol containing 5 per cent. of hydrogen chloride.

Time (hours)	Weight undissolved (grams)
3	0.521
7	0.454
17	0.323
19	0.291
21	0.271

TABLE I.

To establish the presence of methyl glucoside in the dissolved portion, 10 grams of the triacetate were boiled for 7 hours with 500 cc. of methyl alcoholic hydrogen chloride. After removal of the undissolved portion (4 grams), the acid solution was neutralised by lead carbonate, filtered and evaporated. The residue consisted of a mixture of crystalline solid and syrup. The crystalline portion was separated, and after purification by recrystallisation, was found to have the characteristics of α-methyl glucoside (m.p. 167 – 169° C.; $[\alpha]_D$ in methyl alcohol = + 163°).

During the reaction of the conversion of cellulose triacetate into methyl glucoside, de-acetylation takes place. This applies both to the insoluble (cf. Irvine and Soutar, J. Chem. Soc., 1920, 119, 1489) and to the soluble products. For instance, in the experiment just described, the undissolved portion of 4 grams was found to consist of material containing only 11.5 per cent. of acetyl. It is obviously of interest to determine whether this material

is merely a partly de-acetylated cellulose triacetate or whether it represents a degradation product. With this object the product was fully re-acetylated by the usual method and yielded a substance containing 46.54 per cent. of acetyl and possessing in chloroform solution an optical rotation of $[\alpha]_D = -8°$. Repetition of the experiment gave comparative results, i.e., the insoluble material contained 15.2 per cent. of acetyl; on re-acetylation the acetyl content was increased to 46.84 per cent.; $[\alpha]_D = -10°$. These results make it perfectly clear that the insoluble material obtained in the experiments represents a partially de-acetylated degradation product.

After re-acetylation, such a product can again be subjected to treatment by boiling methyl alcoholic hydrogen chloride, yielding, as before, soluble and insoluble fractions. The results of such a repeated treatment are shown in Table II.

Cellulose triacetate (16.0 grams)
- → soluble, 3.08 gms.
- → insoluble, 7.36 gms. (15.2% acetyl). Of this, 6.3 gms. were fully re-acetylated and yielded 9.14 gms. (46.84% acetyl; $[\alpha]_D = -10°$).

7.85 gms of this
- → soluble, 3.21 gms.
- → insoluble, 2.16 gms. (5.36% acetyl). Of this, 1.77 gms. re-acetylated to 1.98 gms. (48.77% acetyl; $[\alpha]_D = 0°$).

1.36 gms. of this
- → soluble, 0.609 gms.
- → insoluble, 0.383 gms.

TABLE II.

A study of this table shows that the degradation of cellulose acetate is accompanied by the lowering of the specific

rotation (of the fully acetylated products), an observation which may prove of value as providing a means of determining the relationship of alleged acetyl celluloses to cellulose itself. Further, in spite of the inevitable losses during the repeated manipulation, the total yield of soluble material calculated as methyl glucoside is approximately 83 per cent. of the theoretical. It may be expected, therefore, that this mode of application of the methyl alcoholic hydrogen chloride degradation process may prove useful as a quantitative method. Experiments to establish this are in progress.

The acetyl determinations quoted in this paper were made in the following way:—

A weighed portion of the acetyl derivative was boiled with a solution of approximately N/2 caustic soda for two hours. Sufficient 10 per cent. sulphuric acid was then added to bring the acid concentration to approximately 5 per cent. The solution was then submitted to steam distillation, the distillate being collected in batches of about 350 cc., each of which was titrated with standard alkali. When the same quantity of alkali was required for two successive batches, the distillation was stopped and a correction made by deducting from the titration value of each batch, the limit value attained in the last two batches. Treated in this way, ordinary cellulose triacetate was found to have an acetyl content of 44.1 per cent. (calculated 44.8 per cent). Precautions were taken to exclude carbon dioxide, and a blank determination was made with the reagents.

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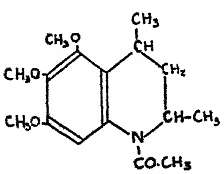
SOME TRIMETHOXY-QUINOLINE DERIVATIVES.

By FRANCIS LIONS, B.Sc., Ph.D.

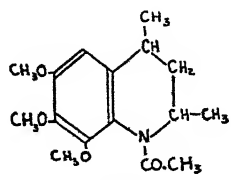
(Read before the Royal Society of New South Wales, Dec. 4, 1929.)

It has been pointed out previously (Lions, Perkin and Robinson, J.C.S., 1925, **127**, 1161) that 6-substituted-3 :4-dialkyloxy acylanilides exhibit the nitric acid reaction of brucine, but that the alkaloid itself is very much more sensitive to this reagent. It was thought that this might be due to a further substitution of the benzene ring of the alkaloid, in particular, to an attached ether linking, because the function of the "second oxygen atom" of strychnine and brucine has not yet been completely elucidated.

In an attempt to gain information on this point 1-acetyl-5 :6 :7-trimethoxy-2 :4-dimethyl-1 :2 :3 :4-tetrahydroquinoline (I) and 1-acetyl-6 :7 :8-trimethoxy-2 :4-dimethyl-1 :2 :3-4-tetrahydroquinoline (II)



(I)



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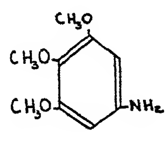
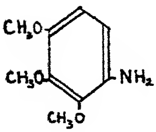


(III)

have been synthesised from 3 :4 :5-trimethoxyaniline (III) and 2 :3 :4-trimethoxyaniline (IV) respectively, by application of Combe's quinoline synthesis (cf. Compt. rend., 1887, **106**, 142; Bull. Soc. Chim., 1888, (iv), **49**, 90), followed by reduction and acetylation. Acetylacetone was condensed with 3 :4 :5-trimethoxyaniline and 2 :3 :4-trimethoxyaniline respectively, to give the Schiff's bases β-(3 :4 :5-

trimethoxyanilino)-propenyl methyl ketone (V) and β-(2:3:4-trimethoxyanilino)-propenyl methyl ketone. Solution of these in cold



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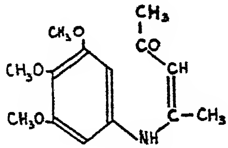

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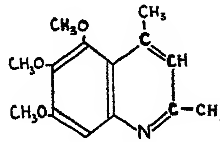
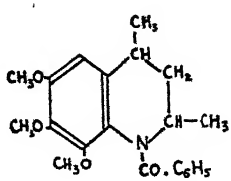


(VI)

concentrated sulphuric acid led to the almost quantitative formation of 5:6:7-trimethoxy-2:4-dimethyl quinoline (VI) and 6:7:8-trimethoxy-2:4-dimethyl quinoline respectively. Reduction of these bases with sodium and boiling ethyl alcohol gave the corresponding tetrahydro bases as colourless oils of constant boiling point. Both yielded oily yellow nitrosoamines when treated in dilute acid solution with sodium nitrite solution. Gentle acetylation with acetic anhydride led to the formation of the amides (I) and (II), of which the former was obtained crystalline. The latter, however, could not be induced to crystallise, nor could the corresponding 1-benzoyl-6:7:8-trimethoxy-2:4-dimethyl-1:2:3:4-tetrahydroquinoline (VII) be obtained in a crystalline condition.



(VII)

The isomers (I) and (II) are 6-substituted-3:4-dialkyloxy-acylanilides further substituted in the benzene ring by a methoxy group. They have the requisite substituent groups previously shown to be necessary for the brucine

reaction. It was found on experiment that both (I) and (II) exhibit almost identical colour reactions with nitric acid, but that these differ widely from the brucine reaction in sensitiveness and in tint. It would thus appear improbable that there is a third ether link attached to the benzene ring of brucine.

The quantitative nature of the quinoline ring closure by means of concentrated sulphuric acid of the Schiff's bases, β-(3:4:5-trimethoxyanilino)-propenyl methyl ketone and β-(2:3:4-trimethoxyanilino)-propenyl methyl ketone, is of interest in connection with the observations of Roberts and Turner on the factors controlling the formation of such derivatives of quinoline (J.C.S., 1927, 1832).

In view of the fact that no substance so far obtained from strychnine or brucine has been definitely proved to contain the quinoline nucleus, it seems of importance to prepare an acylated 5:6-dimethoxy dihydroindole and examine its behaviour towards nitric acid. Such a derivative should show the "brucine reaction," and its sensitiveness towards the reagent may resemble that of the alkaloid more closely—though neither 5:6-dimethoxyindole nor its 1-acetyl derivative resembles brucine in its reaction with nitric acid (cf. Oxford and Raper, J.C.S., 1927, 1625-6). The synthesis of 5:6-dimethoxy-dihydroindole is in progress.

Experimental.

β-(3:4:5-Trimethoxyanilino)-propenyl methyl ketone.

5-Aminopyrogallol trimethyl ether (Graebe and Suter, *Ann.* **340**, 222-4 (1905); 30 grams) was heated with acetylacetone (18 grams) on a steam bath for three hours, during which globules of water separated. The yellow ethereal solution of the oil was well washed with water and dried over sodium sulphate. Removal of portion of the solvent, followed by cooling and scratching, caused the Schiff's

base to crystallise in very pale yellow rhombic prisms. One further crystallisation from ether gave a pure product melting at 101°C. (Found: C, 63.4; H, 7.2. $C_{14}H_{19}O_4N$ requires C, 63.5; H, 7.2%.) This compound is chiefly characterised by the great ease with which it crystallises. Slow evaporation of an ethereal solution can be made readily to yield rhombs over one centimetre in length. It is best purified from ether in which it is only sparingly soluble in the cold. It is very soluble in benzene, chloroform, acetone and ethyl acetate, moderately in alcohol and only very sparingly in light petroleum.

5:6:7-Trimethoxy-2:4-dimethyl quinoline.

The above mentioned Schiff's base (10 grams) was added in small portions with efficient stirring and cooling to ice-cold concentrated sulphuric acid (60 grams). Finally, after standing for 30 minutes in the cold, the pale brown solution was poured into ice-water (600 cc.). This solution was carefully basified with ammonia, when the quinoline separated as a white crystalline powder, which was filtered off, washed well with cold water and dried in vacuo (yield, 8 grams). If the sulphuric acid reaction mixture be poured into a smaller volume of ice-water it is possible to induce the sulphate of the base to crystallise as a voluminous white precipitate. Recrystallised from dilute methyl alcohol, the base was obtained in radiating clusters of long slender needles, m.p. 59° C. (Found: C, 67.7; H, 6.8. $C_{14}H_{17}O_3N$ requires C, 68.0; H, 6.9%.) It is very soluble in most of the usual organic solvents, only moderately so in ether and sparingly in light petroleum. It is practically insoluble in water, but dissolves readily in acids. The solution in cold concentrated sulphuric acid is practically colourless, but becomes dark on warming. Demethylation probably occurs, for on dilution and addition of alkali

there is no precipitate and the solution rapidly changes through violet to a very dark colour.

5:6:7-Trimethoxy-2:4-dimethyl-1:2:3:4-tetrahydroquinoline.

5:6:7-Trimethoxy-2:4-dimethylquinoline (8 grams) was dissolved in boiling absolute ethyl alcohol (100 cc.) and reduced by the rapid addition of sodium (10 grams) in small pieces. After complete solution of the metal most of the alcohol was removed in a current of steam, and the oil which separated from the cooled diluted solution taken up in ether, dried over sodium sulphate, solvent removed and then distilled in vacuo. A colourless viscous oil (7 grams) boiling at 211-214°/13 mm. was obtained. On long standing it solidified to a finely crystalline white solid, m.p. 89°. (Found: C, 66.8; H, 8.1. $C_{14}H_{21}O_3N$ requires C, 66.9; H, 8.4%.) The tetrahydro base dissolves readily in acids. The solution in hydrochloric acid gives the *nitrosoamine* as a pale yellow sticky oil, when treated with sodium nitrite solution in the cold. Solution in twice its weight of acetic anhydride followed by two hours' standing and then 15 minutes' heating on the steam bath led to acetylation of the base. After decomposition of excess of reagent by dilute hydrochloric acid and washing, the pale brown oil was induced to crystallise. Recrystallisation from methyl alcohol gave the pure acetyl derivative in colourless prisms, m.p. 137° C. (Found: C, 65.1; H, 7.8. $C_{16}H_{23}O_4N$ requires C, 65.5; H, 7.8%.) This substance is readily soluble in most of the usual organic solvents with the exception of light petroleum. It dissolves very slowly in cold concentrated sulphuric acid to a colourless solution, which acquires an immediate wine-red colour on the addition of a trace of nitric acid. On standing, the colour fades to an orange. A solution in glacial acetic acid also acquires a wine-red colouration when treated with a

few drops of nitric acid, but the colour appears much more slowly than in the case of brucine and is also of a different tint. On standing it deepens to a purplish red, which then slowly fades to a brown.

4-Aminopyrogallol trimethyl ether.

The hydrochloride of this base has been described by Graebe and Suter (Annalen der Chemie, **340**, 227 (1905)), who prepared the base by the action of sodium hypochlorite on 2:3:4-trimethoxybenzamide and isolated it as the above-mentioned salt. The following process was found better for the isolation of the base in quantity. Ethyl gallate trimethyl ether (Pollak and Feldscharek, Monats. 29, 139-155 (1908)) was nitrated according to the method of Hamburg (ibid., 19, 599 (1898)), and the resulting nitro-ester, m.p. 68-70°, hydrolysed by solution in warm aqueous potassium hydroxide solution. A solution of the resulting 2-nitro-gallic acid trimethyl ether (m.p. 164°; 50 grams) in dilute ammonia was run in a thin stream into a boiling solution of crystallised ferrous sulphate (390 grams) in water (850 cc.), with vigorous shaking. Small portions of concentrated ammonia were then added at intervals until the boiling solution became definitely alkaline, each addition being followed by vigorous shaking. The mixture was then boiled five minutes, filtered, and the 3:4:5-trimethoxy-anthranilic acid recovered from the concentrated filtrate with acetic acid. The yield was almost theoretical. The product was obtained pure in jade green glistening plates, m.p. 140°, by re-crystallisation from ethyl alcohol. (Found: C, 52.7; H, 5.7. Calculated $C_{10}H_{13}O_5N$ requires: C, 52.9; H, 5.7%.) This acid shows a very fine blue-violet fluorescence in alcoholic solution.

A suspension of 3:4:5-trimethoxy anthranilic acid (30 grams) in glycerol (200 grams) was kept vigorously stirred

whilst the temperature was slowly raised to 200°. Carbon dioxide commenced to be evolved at 150°, and the evolution was apparently complete at 190°. The cooled solution was diluted to four times its volume with water and extracted several times with ether. From the combined dark-red ethereal extracts, dried over sodium sulphate, the solvent was removed, and the residual oily base was distilled under diminished pressure. 15 grams of a colourless oil, b.p. 147-8°/15 mm. were collected. (Found: C, 58.8; H, 7.0. Calculated $C_9H_{13}O_3N$ requires C, 59.0; H, 7.1%.) 4-Aminopyrogallol trimethyl ether is practically odourless and darkens rapidly on exposure to air. A dilute solution of the hydrochloride rapidly changes through purple to deep-red with ferric chloride solution. The *acetyl derivative* obtained by the action of acetic anhydride on a solution of the base in dilute acetic acid is a colourless solid, m.p. 90°.

β-(2:3:4-Trimethoxyanilino)-propenyl methyl ketone.

4-Aminopyrogallol trimethyl ether (14 grams) and acetylacetone (9 grams) were heated together on the water-bath for half an hour, when globules of water separated. The oily yellow liquid was dried in ether and finally distilled under diminished pressure, 20 grams of an almost colourless thick oil, b.p. 206-8°/14 mm. being collected. This soon solidified and, after several re-crystallisations from petroleum, ether was obtained in colourless prisms, m.p. 70°. (Found: C, 63.3; H, 7.2. $C_{14}H_{19}O_4N$ requires C, 63.4; H, 7.2%.)

6:7:8-Trimethoxy-2:4-dimethyl quinoline.

β-(2:3:4-Trimethoxyanilino)-propenyl methyl ketone (15 grams) was carefully dissolved in ice-cold concentrated sulphuric acid (90 grams). After standing at room temperature for an hour the clear brown solution was poured

into ice-water and carefully basified with ammonia. The precipitated pale yellow oil was taken up and dried in ether, and finally distilled under diminished pressure. 11 grams of a pale yellow viscous oil were collected, b.p. 198-200°/12 mm. After standing some days this solidified, and by re-crystallisation from petroleum ether was obtained in colourless prisms, m.p. 59.5°. (Found: C, 67.9; H, 6.9; $C_{14}H_{17}O_3N$ requires C, 68.0; H, 6.9%.)

6:7:8-Trimethoxy-2:4-dimethyl-1:2:3:4-tetrahydroquinoline.

The quinoline derivative just described (8 grams) was dissolved in boiling absolute ethyl alcohol (150 cc.), and reduced by the rapid addition of sodium (15 grams) cut in small pieces. After complete solution of the metal the alcohol was removed by steam distillation and the cooled, diluted residue extracted with ether. After drying and removal of the solvent the remaining oil was distilled under diminished pressure, a colourless oil (5 grams) boiling at 173-5°/11 mm. being obtained (Found: C, 66.7; H, 8.3; $C_{14}H_{21}O_3N$ requires C, 66.9; H, 8.4%.) This base is almost odourless. It dissolves readily in dilute mineral acid solutions, and treatment of such solutions in the cold with sodium nitrite solution leads to the immediate production of a viscous oily yellow nitrosoamine. Solution of the base in twice its weight of acetic anhydride, allowing to stand for two hours and then warming on the steam-bath led to the formation of the *acetyl derivative* (1), which was obtained as a pale yellow oil on decomposition of excess of reagent with very dilute hydrochloric acid in which the amide (1) is quite insoluble. The oil could not be induced to crystallise. It dissolves readily in glacial acetic acid, and the solution gives a wine-red coloration with a few drops of concentrated nitric acid. The reaction is very similar to that shown by the isomer described above.

It does not resemble the brucine reaction. Treatment of the tetrahydro base with benzoyl chloride and dilute alkali led to the formation of the *benzoyl derivative* (VII), which was isolated as a very stiff almost colourless gum. It could not be induced to crystallise. Its solution in glacial acetic acid gave an immediate red colouration with nitric acid practically identical with that shown by the acetyl derivative.

In conclusion, the author desires to thank Professor R. Robinson, F.R.S., for his interest in the work, the Royal Commissioners for the Exhibition of 1851 for a Scholarship, and the Chemical Society of London for a grant which defrayed a part of the expenses.

The Universities of Oxford and Sydney.

RESEARCHES ON INDOLES.

Part I.

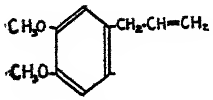
2-METHYL-5:6-DIMETHOXYINDOLE.

By Francis Lions, B.Sc., Ph.D.

(Read before the Royal Society of New South Wales, Dec. 4, 1929.)

The difficulty of obtaining derivatives of 5:6-dihydroxy-indole has already been pointed out (cf. Perkin and Rubenstein, J.C.S. 1926, 357; Oxford and Raper, ibid., 1927, 417). It having become necessary for the author to prepare and study various derivatives of 5:6-dimethoxyindole in connection with the problem of the constitution of the alkaloid brucine, a re-examination has been commenced of the general methods available for the preparation of substituted indole derivatives with a view to rendering these more accessible. Most promising results have been obtained by employing the Japp-Klingemann reaction for the preparation of substituted phenylhydrazones of α-ketoesters and α-diketones, followed by cyclisation of these to indoles a method initiated by Manske, Perkin and Robinson (J.C.S. 1927, 2). Results of such experiments will be described shortly. In the present paper a method is described whereby eugenol methyl ether (I) can be converted into an indole derivative, -2-methyl-5:6-dimethoxyindole. Eugenol methyl ether is a readily accessible substance which occurs in many essential oils, notably in that of the Tasmanian "Huon Pine" (*Dacrydium Franklini*) and in certain species of Melaleuca. On nitration in glacial acetic acid solution it readily yields 5-nitro-4-allyl veratrole (II),

which adds on bromine with extreme ease to give the dibromo compound (III).



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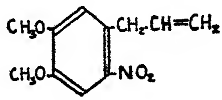

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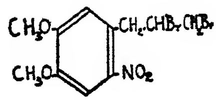
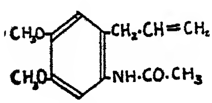


(III)

Foulds and Robinson (J.C.S. 1914, 1969) showed that by a variation of Lipp's indole synthesis (cf. Ber. (1884), **17**, 1067, 2507), 6-nitro safrole could readily be converted into 2-methyl-5:6-methylene-dioxy indole. It has now been found that 5-acetylamino-4-allyl veratrole (IV)—which is obtained when 5-nitro-4-allyl veratrole is reduced with tin and hydrochloric acid and the resulting base treated with acetic anhydride—readily yields a dibromide (V), which on treatment with strong potassium hydroxide solution is converted into 2-methyl-5:6-dimethoxy indole (VI).



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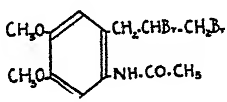

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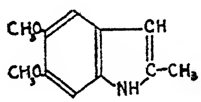

(VI)

Experimental.

5-Nitro-4-allylveratrole dibromide.

5-Nitro-4-allyl veratrole (Lions, Perkin and Robinson, **J.C.S. 1925,** 1168; 5 grams), dissolved in cold carbon tetrachloride (25 cc.), was treated gradually with a solution of bromine (3.7 grams) in carbon tetrachloride (25 cc.) in the cold. Bromination was practically instantaneous, most of the dibromide being at once precipitated as a dark sticky oil. Excess petroleum ether was added, and after standing 10 minutes the liquid was decanted from the precipitated oil, which crystallised after two days' contact with alcohol.

It was obtained pure by re-crystallisation from acetic acid, in nodules of salmon coloured prisms, m.p. 111° C. (decomp.). (Found: C, 34.8; H, 3.5. $C_{11}H_{13}O_4NBr_2$ requires C, 34.5; H, 3.5%). The substance is readily soluble in alcohol, ethyl acetate, benzene, and acetic acid, but is almost insoluble in chloroform, carbon tetrachloride and ligroin. On heating it melts to a pale yellow liquid with vigorous gas evolution.

5-Acetylamino-4-allylveratrole dibromide.

To a solution of 5-acetylamino-4-allylveratrole (Lions, Perkin and Robinson, loc. cit.; 10 grams) in chloroform (40 cc.) was gradually added with stirring and efficient cooling a solution of bromine (7 grams) in chloroform (10 cc.). Bromination was practically instantaneous; and finally most of the chloroform was distilled off and the residue mixed with alcohol (30 cc.); the dibromide crystallised and was filtered off (14 grams). Re-crystallised twice from dilute acetic acid and twice from ethyl acetate, it was obtained in colourless prisms, m.p. 160-161° C. (Found: C, 40.1; H, 4.4. $C_{13}H_{17}O_3NBr_2$ requires C, 39.5; H, 4.3%.) It is only sparingly soluble in most of the usual organic solvents, except glacial acetic acid, in which it dissolves with great readiness. Such a solution shows the "brucine reaction" with nitric acid, but the test is not nearly so sensitive as with the unbrominated substance.

2-Methyl-5:6-dimethoxy indole.

To a solution of 5-acetylamino-4-allylveratrole dibromide (15 grams) in boiling ethyl alcohol (150 cc.), a solution of potassium hydroxide (40 grams) in water (40 cc.) was added. The liquid was then refluxed for twenty minutes, cooled and poured into water. The flocculent precipitate which gradually separated from the milky fluid was filtered off and macerated with dilute alcohol, when a sticky solid

(6 grams) was obtained. It was difficult to purify owing to its inability to crystallise rapidly. However, by repeated crystallisations from boiling petroleum ether, it was eventually obtained in white micaceous plates, m.p. 91° C. (Found: C, 69.1; H, 6.81. $C_{14}H_{13}O_2N$ requires C, 69.1; H, 6.8.) The crystals became reddish brown on exposure to air. Acids rapidly cause reddening; a dilute solution in glacial acetic acid becomes dark brown at once on treatment with a drop of nitric acid. Alcoholic solutions give a fine magenta coloration with a solution of p-dimethylaminobenzaldehyde and a drop of dilute hydrochloric acid.

In conclusion, the author desires to express his gratitude to the Royal Commissioners for the Exhibition of 1851 for a scholarship, and to the Chemical Society of London for a grant which defrayed the cost of the materials employed.

The Universities of Oxford and Sydney.

CYANOGENETIC GLUCOSIDES IN AUSTRALIAN PLANTS.

PART II.

A.—EREMOPHILA MACULATA.

THE NATIVE FUCHSIA.

By HORACE FINNEMORE, B.Sc. (Lond.), F.I.C.,

and

CHARLES BERTRAM COX, B.Sc. (Syd.),
Research Officer, C.S.I.R.

(Read before the Royal Society of New South Wales, Dec. 4, 1929.)

As long ago as 1887 this plant was classified as a stock poison by Bailey and Gordon in "Plants reputed poisonous to Stock," and in 1897 it was included in the same category in "Plants reputed poisonous to Stock in Australia," by J. H. Maiden, who reported that it was often sent to Sydney as a suspected plant, although some persons look on it as good fodder. Maiden stated that it did not appear dangerous to stock accustomed to eat it, but to others, travelling stock particularly, it is considered to be deadly. The effects seemed worse after rain, and it was thought to be more dangerous when in fruit.

In 1910 our knowledge advanced a step further when Brunnich and Smith[1] recorded the presence of a glucoside which yielded hydrocyanic acid and an aldehyde, similar in its properties to benzaldehyde, although the amount of material did not permit these workers to identify the latter. The amount of hydrocyanic acid was considerable (0.297

per cent.), but not so high as that recorded in the present paper.

During May of this year in connection with an investigation undertaken by the Poison Plants Committee into the loss of stock on the Georgina River, North Queensland, two specimens of Native Fuchsias were received from Mr. J. A. Wilson, Walgra, North Queensland. These were labelled "Fine leaf Fuchsia" and "Broad leaf Fuchsia," and were identified by Mr. E. Cheel, Curator of the National Herbarium, to whom our thanks are due, as *Eremophila Goodwinii* and *E. maculata* respectively. The former gave a negative and the latter a strongly positive test for hydrocyanic acid when treated with sweet almonds, and this sample was almost but not quite free from the appropriate enzyme. About 9 lbs. of leaves, collected in July this year, were subsequently obtained from the same source; these arrived in excellent condition thanks to the care that had been taken to dry them in the air before despatch.

On hearing from Mr. Brunnich that it was not his intention to continue work on this plant, we decided to undertake its investigation, particularly as much evidence connected it with loss of stock, although opinion seemed divided locally between this plant and Gidgea, *Acacia Georgina*, as the chief contributing cause. We have succeeded in isolating the cyanogenetic glucoside, and have identified this as prunasin, formerly called Fischer's glucoside, because this worker obtained[2] it from amygdalin by controlled hydrolysis. This substance has been obtained from natural sources by Hérissey[3], who separated the glucoside of *Prunus Laurocerasus*, prulaurasin, into its two optically active isomers, prunasin and sambunigrin.

Prunasin has also been isolated by Power and Moore in small quantity from the bark[4] and leaves[5] of the pharmacopoeial drug, *Prunus serotina.* It is of interest to recall that sambunigrin was isolated by us last year from two Australian Acacias, viz., *Acacia glaucescens* and *A. Cheelii*[6]

Quantitative Determination of the Hydrocyanic Acid.

Four grams of the finely disintegrated leaves were mixed with five grams of crushed sweet almonds and 500 cc. of water and allowed to stand with occasional shaking for 24 hours at room temperature in a tightly closed flask. Steam was then blown through the mixture and the distillate collected in a dilute solution of potassium hydroxide. After acidification the hydrocyanic acid was titrated in the presence of sodium bicarbonate by means of N/10 iodine solution, of which 24.4 cc. were required. This figure corresponds to 0.824 per cent. of hydrocyanic acid, and as the material, dried at 100°, lost 11.8 per cent. of moisture, the water-free leaves contained 0.934 per cent. Calculating from this the amount of glucoside in the leaves dried at 100°, it is seen to be slightly over 10 per cent., and this amount was actually isolated.

Presence of Enzyme.

It has been mentioned above that the sample contained a small amount of enzyme, as it gave only a trace of hydrocyanic acid when moistened with water, whilst a much increased yield was obtained when additional enzyme from sweet almonds was added. In the sample examined by Brunnich and Smith[7], the leaves contained no enzyme at all, but apparently this was present in the fruits, as when macerated together they yielded distinct indications of hydrocyanic acid. We have only been able to examine a single fruit, and our experiment with that showed it to

contain glucoside but no enzyme, but we attach no significance to this single experiment. Brunnich and Smith, however, seemed to ascribe the fatal results obtained experimentally by H. O'Boyle, M.R.C.V.S., to the presence of a few fruits in the sample, and, moreover, consider that some support is given to the popular idea that the plant is most dangerous when in fruit.

Another sample, collected at Nyngan, N.S.W., in September, 1929, gave the following result:

Leaves (air dried) .. .. 0.140% HCN
Whole flowers (air dried), 0.074% HCN

The leaves, flowers and the one fruit all contained glucoside. The leaves contained some enzyme, but insufficient to give the maximum yield of hydrocyanic acid. Both the flowers and the fruit were devoid of enzyme.

Identification of Benzaldehyde.

It has been observed that when the leaves were treated with sweet almonds the odour of benzaldehyde was apparent. For the isolation of this substance 200 grams were macerated with water and sweet almonds for several hours. The product was then steam distilled. The distillate contained globules of oil heavier than water; it was extracted with ether and the solvent evaporated at the ordinary temperature. A phenyl hydrazone was readily prepared from the residual oil; this melted at 154°, and was identified as that of benzaldehyde by the method of mixed melting-points.

Isolation of the Glucoside.

For the isolation of the cyanogenetic glucoside the method described by the present authors[8] for the isolation of sambunigrin was employed. One hundred grams of the air-dried leaves were extracted in a Soxhlet with ether.

After two hours a portion of the green extract gave a positive reaction for hydrocyanic acid by the picrate test, and after a further one hour's extraction a crystalline deposit had separated on the sides of the flask. This proved to be the glucoside, which, when re-crystallised from a mixture of ethyl acetate and chloroform, was obtained in colourless glistening needles melting at 147-148°. Many such extractions have been carried out; the highest yield of crude glucoside from the above quantity of leaves was 8.8 grams, which is 98 per cent. of that indicated from the amount of hydrocyanic acid obtained. The extraction is slow, 70 hours being required to obtain the maximum yield, but as the process requires little attention, this is not a serious disadvantage. If a comparison is made with the process employed by Power and Moore for the isolation of prunasin from the sources mentioned, it will be seen that it possesses striking advantages as regards yields.

From the leaves of *Prunus serotina,* containing 0.09% of glucoside, calculated from the hydrocyanic acid liberated, they obtained 0.25 gram of pure glucoside in the form of its acetyl derivative from 3.78 kilograms. The bark contained 0.81%, and they isolated only 3% of the total glucoside present.

Analysis.

0.2106 gave 0.4423 CO_2 and 0.1098 H_2O, whence C = 57.26; H = 5.79.

$C_{14}H_{17}NO_6$ requires C = 56.96; H = 5.76.

0.6134 gram dissolved in sufficient distilled water to produce 50 cc. gave in a 2 dcm. tube at 17.5°, $\alpha_D - 0.68°$, whence $[\alpha]_D^{17.5} = -27.7°$.

Preparation of Acetyl Derivative.

The *acetyl* derivative was prepared by heating 3 grams of the pure glucoside with 60 grams of acetic anhydride

and 10 grams of sodium acetate for one and a half hours. The excess of acetic anhydride was distilled off, and on the addition of water the acetyl derivative separated and rapidly crystallised. It was purified by twice re-crystallising from dilute alcohol, when it melted sharply at 134°.

Analysis.

0.2166 gave 0.4526 CO_2 and 0.1068 H_2O, whence C = 56.97 and H = 5.49.

$C_{14}H_{13}(COCH_3)_4NO_6$ requires C = 57.02 and H = 5.40.

0.4970 gram dissolved in ethyl acetate sufficient to produce 50 cc. gave in a 2 dcm. tube at 16°, α_D^{16} - 0.47°, whence $[\alpha]_D^{16}$ = - 23.6°

These figures agree with those obtained for *l*-mandelonitrile glucoside, from the hydrolysis of amygdalin, and prunasin, from natural sources. A comparison of the constants obtained for this glucoside, with those obtained by the workers previously mentioned, is given below.

	Fischer.[8]	Hérissey.[9]	Power and Moore.[10]	**Eremophila glucoside.**
Carbon	56.7	—	56.9	57.26
Hydrogen ..	6.0	—	6.0	5.79
Optical Rotation ..	$[\alpha]_D^{20}$ — 26.9	$[\alpha]_D$ - 27.10	$[\alpha]_D$ — 29.6	$[\alpha]_D^{17.5}$ — 27.7
Melting Point	147-9°	138-9°	145-7°	147-8°

Tetracetyl Derivatives.

	Hérissey.	Power and Moore.	**Eremophila glucoside.**
Carbon		56.6	56.97
Hydrogen		5.6	5.49
Optical Rotation	$[\alpha]_D$ — 24.0	$[\alpha]_D$ — 24.0	$[\alpha]_D^{16}$ — 23.6
Melting Point ..	134-6°	136-7°	134°

The above figures prove conclusively the identity of this substance with *l*-mandelonitrile glucoside, or prunasin.

Prunasin has been isolated by a slight modification of the process given herein from the bark of *Prunus serotina* by F. Willson White, and one of us (H.F.), and its identity with the glucoside now isolated from *Eremophila maculata*, has been confirmed by the mixed melting point method.

B.—THE PRESENCE OF ENZYMES IN FODDER PLANTS AS A FACTOR IN THE POISONING OF STOCK.

With SUZANNE KATE REICHARD.

The isolation of sambunigrin and prunasin has afforded the opportunity of testing, by means of these cyanogenetic glucosides, for the presence of enzymes in plants capable of decomposing them, and liberating the hydrocyanic acid which they contain. This enquiry seemed necessary from two points of view. In the first place our investigation of *Eremophila maculata* showed that the sample of dried plant employed contained practically no enzyme, and that, therefore, only a trace of hydrocyanic acid was liberated, and, in spite of the presence of an exceptionally large amount of glucoside, there still remained some doubt whether this plant was poisonous or not. Another plant, *Heterodendron olaeifolium* recently submitted for examination, similarly contained a large amount of cyanogenetic glucoside, but not sufficient enzyme to give a positive reaction until enzyme from another source had been added. In this particular case it has been recorded by Petrie that only one-third the amount of acid was liberated before the addition of emulsin.

From the second point of view it seemed desirable to repeat Petrie's work, during which he examined some 150 grasses of New South Wales for the presence of β. enzymes. By using amygdalin as his reagent, his results may only be considered as valid for the presence of that particular enzyme which is capable of splitting amygdalin, viz., β. amygdalase, and apparently both these are somewhat restricted in their distribution.

Although it soon became evident that amygdalin was rarely decomposed by plant extracts, prunasin and sambunigrin are readily affected, indicating a wide distribution of β. enzymes.

In using prunasin as a test for β. enzymes, we have been anticipated by Armstrong and his co-workers, who have claimed for its use in place of amygdalin, an important advance in technique. These workers found that of some thirty plants examined, which decomposed over 10 per cent. of the prunasin to which they were subjected, only three of these similarly decomposed 10 per cent. of amygdalin.

For the purpose of our experiments a series of commonly occurring plants was collected in the grounds of the University, about two grams of the fresh material was cut up finely with scissors, and mixed with 4 ccs. of the solutions of amygdalin, prunasin and sambunigrin of equivalent strength of hydrocyanic acid. These were incubated at 40° to 42°, and the intensity of colour of picrate paper taken as a rough measure of the extent of hydrolysis. Of 25 specimens, 5 gave equal intensity, amygdalin yielded an excess of colour in two cases, prunasin in 7, and sambunigrin in 11. Six specimens of native grasses, kindly collected for us by Mr. Cheel on November 24th at Bullia Island, gave evidence of the presence of enzyme, but in this case all gave equal intensity when incubated at 40° overnight.

Among the material we have tested special mention should be made of the unripe pods of *Acacia suaveolens*. We found a striking difference between the effect produced on the three glucosides, prunasin being most readily attacked, then sambunigrin, and amygdalin not at all. On repeating these experiments three weeks later no hydrocyanic acid was liberated.

It then occurred to us there might be some connection between the apparent ease with which prunasin is decomposed by the enzyme of this plant, and the fact that local observers have ascribed the poisoning of stock on the Georgina River to the eating of the pods of an allied plant, Gidgea, *Acacia Georgina,* rapidly fatal results having been observed after eating them. Unfortunately, it has not been possible to obtain fresh specimens of these pods from that district for trial, but through the kindness of Mr. Cheel we have been supplied with herbarium specimens from the National Herbarium, and although these were very old, having been collected in 1910, they still retained sufficient enzyme to decompose prunasin. This result has been confirmed by specimens obtained from the National Herbarium, Brisbane, a few pods and leaves being kindly sent to us by Mr. C. T. White, the Government Botanist. Both pods and leaves showed a striking difference with the three glucosides named; in half an hour's incubation amygdalin was not decomposed, but a decidedly positive reaction was obtained with both prunasin and sambunigrin. It is our intention to attempt a quantitative examination of this subject as soon as the necessary material is available. Meanwhile an attempt will be made to test the validity of the suggested inter-relation of *Eremophila maculata* and *Acacia Georgina* and its bearing on the poisoning of stock on the Georgina River.

Summary.—The ease with which prunasin and sambunigrin are decomposed, as compared with amygdalin by the enzymes of plants, is shown, and the significance of the presence of enzymes in fodder plants is illustrated.

The authors acknowledge with grateful thanks their indebtedness to the University of Sydney for laboratory facilities, to Professor J. C. Earl for placing the facilities of his laboratory for the analysis of prunasin at their dis-

posal, and to the Council for Scientific and Industrial Research for a grant to the Poison Plants Committee, that has enabled one of them (C.B.C.) to collaborate in this work.

References.

1. Queensland Agricultural Journal, 1910, 25, 291-293.
2. Ber. d. d. chem. Ges, 1895, 28, 1508.
3. Archiv. d. Pharm., 1907, 245, 463, 474, 641.
4. Jour. Chem. Soc. Trans., 1909, 95, 243-261.
5. Jour. Chem. Soc. Trans., 1910, 96, 1099.
6. This Journal, 1928, 62, 369.
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8. *loc. cit.*
9. *loc. cit.*
10. *loc. cit.*
11. *loc. cit.*

Department of Materia Medica and Pharmacy,
The University, Sydney.

ABSTRACT OF PROCEEDINGS

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

MAY 1, 1929.

The Annual Meeting, being the four hundred and eighty-fourth General Monthly Meeting of the Society, was held at the Royal Society's Rooms, 5 Elizabeth Street, Sydney, at 8 p.m.

Mr. W. Poole, President, in the Chair.

Twenty-two members were present.

The Minutes of the General Monthly Meeting of the 5th December, 1928, were read and confirmed.

It was announced that the following members had died during the recess:—Sir George Knibbs, Harry Ambrose Russell, and Richard Teece.

The President spoke of the loss sustained through the death of Sir George Knibbs and asked the meeting to endorse the following motion, carried at the Council meeting on 23rd March, 1929:

"That the Council of the Royal Society of New South Wales record its appreciation of the valuable assistance to the Society by the late Sir George Knibbs over forty-eight years. As a member of the Council for thirteen years, during which time he served as President and Vice-President, and for nine years as Honorary Secretary, he placed his great abilities as an organiser at the service of the institution. More particularly his en-

quiries into the Title possessed by the Society to its former house in Elizabeth Street, and his survey of boundaries were important to the Society. He contributed twenty-eight papers to the Journal and Proceedings and his contributions of Vital Statistics continued to within twelve months of his death."

This was done, those present standing in silence.

Letters were read from Miss Cambage, Mrs. Darley, Lady Knibbs, Mrs. MacCulloch, Mrs. Russell, Miss Teece and Mrs. Willington expressing thanks for the Society's sympathy in their recent bereavements.

The certificates of four candidates for admission as ordinary members were read; one for the second and three for the first time.

The following gentleman was duly elected an ordinary member of the Society:—Henry George Pyke.

The Annual Financial Statement for the year ended 31st March, 1929, was submitted to members and, on the motion of Professor Chapman, seconded by Mr. Cheel, was unanimously adopted.

ROYAL SOCIETY OF NEW SOUTH WALES.

Statement of Receipts and Payments for the Year ended 31st March, 1929.

GENERAL ACCOUNT.

Dr. Cr.

RECEIPTS.

	£ s. d.	£ s. d.	£ s. d.
To Balance — 31st March, 1928			1053 4 1
„ Revenue—			
Subscriptions		610 16 0	
Rents		490 18 7	
Sundry Receipts ..		151 11 11	
Government Subsidy ..		600 0 0	
Interest — Government Bonds and Stocks ..		1364 10 0	
			3217 16 6

	£ s. d.	£ s. d.	£ s. d.
„ Donations—			
Liversidge Bequest ..	500 0 0		
Add Interest	8 16 8		
		508 16 8	
Walter Burfitt Prize Fund—Interest ..		26 16 0	
			535 12 8
„ J. H. Maiden Memorial		15 14 6	
Interest		18 7 6	
			34 2 0
„ Clarke Memorial Fund—Interest			74 19 3
„ Royal Society's Fund—Interest			169 12 0
„ Royal Society's House—Building Investment Loan Fund			4605 5 3
			£9690 11 9

PAYMENTS.

	£ s. d.	£ s. d.	£ s. d.
By Administrative Expenditure—			
Salaries and Wages—			
Office Salary and Accountancy Fees ..	291 15 0		
Assistant Librarian	53 0 0		
Caretaker	210 3 7		
		554 18 7	
Printing, Stationery, Advertising and Stamps & Telegrams	45 1 4		
Office Sundries, Stationery, etc.	5 9 9		
Advertising	13 6 0		
Printing	77 13 0		
		141 10 1	
Rent, Rates, Taxes and Services—			
Rent	1517 7 4		
Electric Light & Gas	92 12 10		
Insurance	24 9 0		
Rates	321 11 1		
Telephone	18 6 1		
		1974 6 4	

Printing & Publishing			
Society's Volume—			
Printing, etc.	306 3 1		
Bookbinding	48 8 4		
		354 11 5	
Library—			
Books & Periodicals	76 14 2		
Bookbinding	94 13 9		
		171 7 11	
Sundry Expenses—			
Legal Expenses ..	104 5 6		
Repairs	2 11 0		
Lantern Operator ..	8 17 6		
Bank Charges ..	0 4 10		
Clarke Memorial Fd.	0 11 0		
Sundries	51 12 8		
		168 2 6	
			3364 16 10
„ Interest—			
Union Bank of Australia Ltd. ..		6 8 9	
Royal Society's Fund		205 4 8	
Clarke Memorial Fund		74 19 3	
Building Loan Fund		115 1 9	
Maiden Memorial Fund		18 7 6	
			420 1 11
„ Cost of removing Basement Library			231 4 0
„ Architectural Competition			768 2 7
„ Government Bonds and Stock			2737 9 3
„ Building Conversion Fund			2000 0 0
„ Balance—31st March, 1929—			
Union Bank of Australia Ltd. ..		165 16 1	
Cash on Hand		3 1 1	
			168 17 2
			£9690 11 9

Compiled from the Books and Accounts of the Royal Society of New South Wales, and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D., Honorary Treasurer.
(Sgd.) W. PERCIVAL MINELL,
Chartered Accountant (Aust.), Auditor.

Sydney, 17th April, 1929.

BALANCE SHEET AS AT 31st MARCH, 1929.

LIABILITIES.

	£	s.	d.	£	s.	d.
Investment Fund—						
Clarke Memorial Fund	1243	18	6			
Walter Burfitt Prize Fund	537	7	9			
Investment Fund	3400	1	9			
Liversidge Bequest	508	16	8			
				5690	4	8
Building and Investment Loan Fund ..				4983	6	10
J. H. Maiden Memorial				376	15	0
Accumulated Funds				29,324	13	4
				£40,374	19	10

ASSETS.

	£	s.	d.	£	s.	d.
Cash—						
Union Bank of Australia, Ltd. ..	165	16	1			
Petty Cash	3	1	1			
				168	17	2
Government Bonds and Stock				27813	10	2
Building Conversion Fund				2000	0	0
Sundry Debtors—						
For Rents	99	2	6			
For Subscriptions in arrears ..	443	10	0			
				542	12	6
Library—						
Insurance Valuation				8460	0	0
Office Furniture—Insurance Valuation				1050	0	0
Pictures—Insurance Valuation				180	0	0
Microscopes—Insurance Valuation ..				120	0	0
Lantern—Insurance Valuation				40	0	0
				£40,374	19	10

Compiled from the Books and Accounts of The Royal Society of New South Wales, and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D., Honorary Treasurer.
(Sgd.) W. PERCIVAL MINELL,
Chartered Accountant (Aust.), Auditor.

Sydney, 17th April, 1929.

INVESTMENT FUND.

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31st MARCH, 1929.

RECEIPTS.

	£	s.	d.	£	s.	d.
To Balance—31st March, 1928				4910	11	9
„ Interest—						
Clarke Memorial Fund	74	19	3			
Walter Burfitt Prize Fund	26	16	0			
Liversidge Bequest	8	16	8			
Investment Fund	169	12	0			
				280	3	11
„ Liversidge Bequest				500	0	0
				£5690	15	8

PAYMENTS.

	£	s.	d.
By Expenses—Clarke Memorial Fund	0	11	0
„ Balance—31st March, 1929	5690	4	8
	£5690	15	8

On the motion of Professor Chapman, seconded by Mr. Cheel, Mr. W. P. Minell was duly elected Auditor for the current year.

The Annual Report of the Council was read, and on the motion of Dr. Noble, seconded by Mr. A. D. Olle, was adopted.

Report of the Council for the Year 1929-30.
(1st May to 23rd April.)

The Council regrets to report the loss by death of nine ordinary members. Eight members have resigned. On the other hand, eleven ordinary and one honorary members have been elected during the year. To-day (23rd April, 1929) the roll of members stands at 341.

During the Society's year there have been eight general monthly and ten ordinary and three special Council meetings.

Four Popular Science Lectures were given, namely:—

June 21—"Science and Industry," by Assoc.-Professor F. A. Eastaugh, A.R.S.M., F.I.C.

July 19—"Australian Butterflies," by G. A. Waterhouse, D.Sc., B.E.

August 23—"Elements of Geophysical Prospecting," by E. C. Andrews, B.A., F.G.S.

September 20—"Some Problems of the Grazing Industry in Arid Australia," by Professor T. G. B. Osborn, D.Sc., F.L.S.

Meetings were held throughout the Session by the Sections of Geology and Physical Science.

The Section of Industry during the year again devoted its attention to visiting several industrial establishments.

Tweny-one papers were read at the monthly meetings and covered a wide range of subjects. In most cases they were illustrated by exhibits of interest.

Lecturettes were given at the monthly meetings in June, July, August, September and October, by Dr. R. J. Noble, Mr. James Nangle, Mr. T. Ranken, Professor O. U. Vonwiller and Professor J. C. Earl respectively.

The monthly meeting on November 7th, 1928, was devoted to a series of short addresses for the purpose of celebrating the bi-centenary of the birth of Captain James Cook. Addresses were given by Messrs. W. Poole, W. Gale, Sir Edgeworth David, Professor H. G. Chapman, Mr. R. H. Cambage and Sir Joseph Carruthers respectively.

The Annual Dinners for 1928-29 and for 1929-30 took place at the Union Refectory, University of Sydney, on Thursday, 26th April, 1928, and 18th April, 1929, respec-

tively. We were honoured on both occasions by the presence of His Excellency Sir Dudley Rawson Stratford de Chair, K.C.B., M.V.O., Governor of New South Wales. The Hon. F. S. Boyce, M.L.C., Attorney-General, represented the Government in 1928. The Presidents of many societies were the guests of the Society on both evenings.

The Council has awarded the Clarke Memorial Medal to Professor Ernest Willington Skeats, D.Sc., A.R.C.S., F.G.S.

On Thursday, 7th February, 1929, an informal meeting of members was held for the purpose of extending a welcome to Professor Johannes Schmidt, leader of the Dana Expedition, and his staff.

The following members have been honoured during the year:—Professor H. G. Chapman, M.D., Director of Cancer Research, Sir George Julius, Knights Bachelor, Professor Griffith Taylor, Professor of Geography in the University of Chicago, Mr. E. C. Andrews, President, Australasian Institute of Mining and Metallurgy, Dr. H. S. Wardlaw, President, Linnean Society of New South Wales.

WALTER BURFITT PRIZE:—A Walter Burfitt Prize is to be awarded this year. A large number of nominations have been received but the adjudication has not yet been made.

MAIDEN MEMORIAL PAVILION:—A site has been selected in the Botanic Gardens, Sydney, for the erection of the Maiden Memorial Pavilion. It is expected that the erection will begin in the near future.

The donations to the library have been as follows:—1225 parts, 71 volumes, 60 reports, 1 calendar and 1 catalogue.

SCIENCE HOUSE:—Despite many efforts to bring about an agreement with the Linnean Society of New South Wales and the Institution of Engineers, Australia, it is not yet possible to commence the erection of the new Science House. The Government of New South Wales is awaiting agreement to make the site available and the Royal Society is eager to commence building the new house. A competition has been held, as a result of which Messrs. Peddle, Thorp and Walker have been selected as architects. It is hoped that in the near future an agreement will have been reached and the building commenced.

OBITUARY.

RICHARD HIND CAMBAGE, C.B.E., F.L.S., was born at Milton in New South Wales on 7th November, 1859, and died on 29th November, 1928, aged 69 years.

At the age of 18 he began his career as an articled surveyor. After qualifying as a licensed surveyor, Mr. Cambage joined the Department of Mines in 1885 as a mining surveyor. In 1902 he was appointed Chief Mining Surveyor, a position he held until 1916 when he was appointed Under Secretary for Mines. This latter position he held until his retirement in 1924.

Mr. Cambage was elected a member of this Society in 1904 and became a member of the Council in 1908 and remained an office-bearer from then on to his death, a period of twenty years. He was elected President in 1912 and again in 1923; he was Vice-President in 1913, 1924 and 1928, and for twelve years held the position of Hon. Secretary. His genial personality, his unfailing tact, his administrative ability and his wide scientific knowledge and experience made him an ideal President and Hon. Secretary and in these capacities he rendered invaluable

service to the Society, and his death left a gap not easy to fill.

He contributed 29 papers to the Society's proceedings, most of which were on botanical subjects. He had a wonderful knowledge of the distribution of plants in Australia and in his field work gave particular attention to the distribution of plants in relation to soil conditions and in this subject he was a recognised authority. He carried out an extensive series of investigations on the growth of Acacia seedlings, the results of which are published in the Society's volumes. His public activities were not limited to the Royal Society. He was a foundation member of the Institution of Surveyors, of which society he was three times President, and for fifteen years he was a member of the Board of Examiners for Licensed Surveyors. For some years he conducted the Surveying classes at the Sydney Technical College.

He was for many years a member of the council of the Linnean Society of New South Wales and a past President of that Society. In 1904 he was elected a Fellow of the Linnean Society of London.

He took a prominent part in the meetings of the Australasian Association for the Advancement of Science and at the time of his death was its President. He was closely associated with the establishment of the Australian National Research Council, of which body also he was President at the time of his death.

In all his varied activities he has left behind a wonderful record of faithful public service.

Cecil West Darley, I.S.O., M.I.C.E.—The late C. W. Darley was born in Wingfield, County Wicklow, Ireland, in 1842. He arrived in Australia in 1867 and

entered the service of the New South Wales Government as Resident Engineer for Newcastle and district. In 1881 he was promoted to the position of Chief Assistant Engineer in the Harbours and Rivers Branch of the Public Works Department and was eight years later promoted to the position of Engineer-in-chief of that branch. In 1896 Mr. Darley was appointed Engineer-in-chief of the Public Works Department, which position he held until 1901 when he was sent to London by the New South Wales State Government as Consulting and Inspecting Engineer. He died in London on 18th October, 1928, aged 86 years.

Mr. Darley was elected a member of the Royal Society in 1876, so that at the time of his death he had been a member for 52 years. He contributed three papers on Engineering subjects to the proceedings of this Society. He was at one time a member of the Council and occupied the position of its President in 1892 and 1893.

Edward Patrick Fleming.—The late Mr. Fleming was born in Parramatta in 1875 and entered the Railway service as a lad. Later he joined the Lands Department and rapidly rose through various ranks until he became head of the Department as Under Secretary for Lands.

Recognising his remarkable administrative ability, the Prime Minister of the Commonwealth in 1926 appointed Mr. Fleming to the Federal Development and Migration Commission for a period of five years. When, in 1927, the city of Sydney was placed under a commission, Mr. Fleming was chosen by the State Government of New South Wales to be Chief Civic Commissioner, this position he held at the time of his death in 1928, and he filled it to the satisfaction of all political parties.

He was elected a member of this Society in 1922.

George Handley Knibbs, K.C.M.G.—The late G. H. Knibbs was born in Sydney on June 13th, 1858, and was educated in his native town. In 1877 he entered the service of the State Government in the Land Survey Department, where he remained until 1889; he was then appointed Lecturer in Surveying at the Sydney University and started in private practice as a licensed surveyor. In 1904 he and the late J. W. Turner were appointed commissioners by the New South Wales Government to report upon the systems of education in Europe and America; a most valuable report was presented upon their return. Soon after he was appointed Superintendent of Technical Education for New South Wales. In 1905 he was appointed Commonwealth Statistician. This position he held until 1921, when the Commonwealth Government appointed him to take charge of the newly-formed Bureau of Science and Industry. From this latter position he retired in 1926 owing to ill-health, and he died on the 30th March, 1929, aged 70 years.

His connection with the Royal Society of New South Wales began when he was elected a member in 1881. He became a member of Council in 1894 and held the position of Honorary Secretary almost continuously from 1896 to 1906. He was elected President in 1898 and Vice-President in 1902. He contributed 29 papers to the Society's proceedings. He was also connected with many other scientific and professional societies: he was President of the Institute of Surveyors in 1892-3 and again in 1900-1; was President of the New South Wales branch of the British Astronomical Association in 1897-8, and President of the Australasian Association for the Advancement of Science in 1923-24.

Sir George Knibbs received many honours in recognition of his public services. In 1906 he was elected an

Honorary Fellow of the Royal Statistical Society; he was selected as one of the 200 distinguished statisticians to form the International Institute of Statistics, and in 1921 he was elected a Vice-President of the International Engineers' Conference in New York. In 1911 his services to the Empire were rewarded by His Majesty the King conferring upon him the Companionship of the Order of St. Michael and St. George, and in 1923 he was created a Knight Bachelor. Not only was he a great public servant, but he was also a scientist of distinction, a scholar of merit and a man of wide culture. His charm of manner and his unvarying kindness of heart made him hosts of friends all the world over; he was intensely human in his interests and in his outlook on life. To the Royal Society of New South Wales he rendered invaluable service, and although he spent much of the latter part of his life in Melbourne, he always retained his interest in its affairs.

STANHOPE H. MACCULLOCH, M.B., Ch.M.—He was born in New South Wales, was educated at the Sydney Grammar School and then proceeded to the Edinburgh University, where he obtained his medical degree. He then returned to Sydney to practise his profession and became widely recognised as an authority on obstetrics He did a vast amount of work in an honorary capacity and was closely associated with the establishment and running of the Women's Hospital, Crown Street, Sydney. For many years he was Examiner in Obstetrics for the Sydney University, and died while still in harness on 25th October, 1928, at the age of 76 years.

He was elected a member of this Society in 1887 and had therefore been a member for 42 years.

HENRY AMBROSE RUSSELL, B.A.—He was born in Sydney in 1865 and was the son of the late H. C. Russell, a former President of this Society. He received his early education at Fort Street School and at the Sydney Grammar School. In the latter he finished as dux and captain. He then entered the Sydney University, won a number of bursaries and took his B.A. degree with first-class honours in Mathematics and Classics, winning the University Medal. He then took up the legal profession and became a member of the firm of Sly and Russell. He specialised in all phases of marine and admiralty law, becoming a recognised authority in this branch of his profession in this State. In addition to his legal work he was closely associated with the direction of several prominent Sydney newspapers.

He was elected a member of this Society in 1897 and remained a member until the time of his death.

RICHARD TEECE, F.I.A., F.F.A., F.S.S.—He died on 30th December, 1928, at the age of 81 years. He was well-known throughout Australia as general manager and actuary of the Australian Mutual Provident Society and had a world-wide reputation as an actuary.

He was born in New Zealand in 1847. In 1865 he matriculated and entered the Sydney University. In July, 1866, he entered the service of the Australian Mutual Provident Society and in 1890 he became general manager, a position he held for 27 years, retiring in 1917.

Among other positions, Mr. Teece was a Fellow of the Institute of Actuaries of Great Britain and Ireland, a Fellow of the Faculty of Actuaries of Scotland, a Fellow of the Actuarial Society of America, and a Vice-President of the Permanent Committee of the International Congress of America. Mr. Teece was a foundation member of the

Australasian Association for the Advancement of Science and was for some years its Treasurer.

He was elected a member of the Royal Society of New South Wales in 1899 and remained a member until his death.

WALTER THOMAS WILLINGTON, O.B.E.—Mr. Willington was born in 1849 and died on 1st March, 1929, aged 79 years. His life was devoted mainly to commercial pursuits and he was at one time president of the Chamber of Manufactures of New South Wales.

He was elected a member of this Society in 1917.

The President announced that the following Popular Science Lectures would be delivered this Session:—

July 18—"Cancer Research," by Professor H. G. Chapman, M.D.

August 15—"The Occurrence and Origin of Mineral Oil," by C. A. Sussmilch, F.G.S.

September 19—"Psychology of the Individual and his Vocation," by A. H. Martin, M.A., Ph.D.

October 17—"Wireless," by Professor J. P. V. Madsen, D.Sc., B.E.

In accordance with Rule 50, the following alteration to Rule 36, which had been carried at the general monthly meeting held on 5th September last, was, on the motion of the President, seconded by Mr Olle, duly confirmed by the meeting.

Alteration to Rule XXXVI. confirmed at Annual Meeting, May 1st, 1929:—

"The funds of the Society shall be lodged at a Bank named by the Council of Management. Claims against

the Society when approved by the Council shall be paid by cheque signed by two of three members nominated by the Council for that purpose."

The following donations were received:—146 parts, 3 volumes, and 5 reports.

The President, Mr. W. Poole, then delivered his address.

There being no other nominations, the President declared the following gentlemen to be Officers and Council for the coming year:—

President:

Prof. L. A. COTTON, M.A., D.Sc.

Vice-Presidents:

C. ANDERSON, M.A., D.Sc.

Prof. R. D. WATT, M.A., B.Sc.

W. POOLE, M.E., M.Inst.C.E., M.I.M.M., Etc.

Sir GEORGE JULIUS, Kt., B.Sc., B.E., M.I.Mech.E.

Hon. Treasurer:

Prof. H. G. CHAPMAN, M.D.

Hon. Secretaries:

C. A. SUSSMILCH, F.G.S.

R. J. NOBLE, M.Sc., B.Sc., Agr., Ph.D.

Members of Council:

E. C. ANDREWS, B.A., F.G.S.

G. H. BRIGGS, B.Sc., Ph.D.

Assist.-Prof. W. R. BROWNE, D.Sc.

R. W. CHALLINOR, F.I.C., F.C.S.

Prof. J. C. EARL, D.Sc., Ph.D.

Prof. C. E. FAWSITT, D.Sc., Ph.D.

J. NANGLE, O.B.E., F.R.A.S.

A. R. PENFOLD, F.A.C.I., F.C.S.

Rev. E. F. PIGOT, S.J., B.A., M.B.

C. W. O. TYE.

Mr. W. Poole, the outgoing President, then installed Professor L. A. Cotton as President for the ensuing year, and the latter briefly returned thanks.

On the motion of Assist.-Professor W. R. Browne, a hearty vote of thanks was accorded to the retiring President for his valuable address. Mr. Poole briefly acknowledged the compliment.

JUNE 5, 1929.

The four hundred and eighty-fifth General Monthly Meeting was held at the Royal Society's Rooms, 5 Elizabeth Street, Sydney, at 8 p.m.

Professor L. A. Cotton, President, in the Chair.

Seventeen members and one visitor were present.

The Minutes of the preceding meeting were read and confirmed.

The President spoke of the loss sustained through the death of the Rev. E. F. Pigot and asked the meeting to endorse the following motion, carried at the Council emeting on 29th May, 1929:—

> "That the Council of the Royal Society of New South Wales record its appreciation of the valuable assistance rendered to the Society by the late Reverend Edward Francis Pigot, S.J., B.A., M.B., over a period of twenty years. He was a member of Council at the time of his death and had served the Society as a Councillor for a little more than six years. He contributed two papers to the Journal of Proceedings of the Society and his scientific work at Riverview College Observatory in connection with Seismology was known and appreciated world-wide. Father Pigot endeared himself to all with whom he came in contact by his charming and kindly personality."

This was done, those present standing in silence

A letter was read from the Rector of Riverview College expressing thanks for the Society's sympathy in the death of the Rev. E. F. Pigot.

The certificates of four candidates for admission as ordinary members were read; three for the second and one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—Samuel Harry Harris, Joseph William Hawley and Norman Dawson Royle.

The President announced that the Council had awarded the "Walter Burfitt Prize" to Dr. Norman Dawson Royle. whose contributions to medical science are so well known.

The following donations were received:—3 volumes, 81 parts and 4 reports.

THE FOLLOWING PAPERS WERE READ:

1. "Notes on the use of the Aneroid Barometer and Plane Table in Geological Mapping," by H. G. Raggatt, B.Sc., and F. W. Booker, B.Sc.

Remarks were made by Professor Browne, the President and Mr. Poole.

2. "Preliminary Note on New Subgenera of *Productus* and *Strophalosis* from the Branxton District," by F. W. Booker, B.Sc.

Papers 1 and 2 were read by Professor W. R. Browne in the absence of the authors.

3. "The Celluloses of some Australian Plants," by W. G. Arneman, B.Sc., and J. C. Earl, D.Sc., Ph.D.

In the absence of Dr. Earl, the paper was read by Mr. R. W. Challinor.

Remarks were made by Messrs. R. T. Baker and R. W. Challinor.

LECTURETTE:

A lecturette on "The Milky Way" was given by Mr. J. Nangle.

JULY 3, 1929.

The four hundred and eighty-sixth General Monthly Meeting was held at the Royal Society's Rooms, 5 Elizabeth Street, Sydney, at 8 p.m.

Professor L. A. Cotton, President, in the chair.

Twenty-six members and two visitors were present.

The Minutes of the preceding meeting were read and confirmed.

The certificates of two candidates for admission as ordinary members were read; one for the second and one for the first time.

The following gentleman was duly elected an ordinary member of the Society:—Gilbert Fatkin Caley.

The President announced that Professor H. G. Chapman, M.D., would deliver a Popular Science Lecture entitled "Cancer Research," on Thursday, 18th July, 1929, at 8 p.m.

The following donations were received:—277 parts, 9 volumes and 11 reports.

WALTER BURFITT PRIZE:—The Walter Burfitt Prize, consisting of a medal and a cheque for £50, was presented to Dr. Norman Dawson Royle. In doing so, the President said that Dr. Royle had been awarded the "Walter Burfitt Prize" for his contributions to the study of muscular action and his investigations into the problems of muscular paralysis. The prize has been adjudged to him by the Council of the Royal Society, as the Council considers his papers published during the years 1926 to 1928 to be those of the highest scientific merit carried out in the Dominions of Australia and New Zealand. Dr. Royle has been engaged for nearly fifteen years in research into the manner in which the contraction of muscles within the body are controlled by the nervous system. His discoveries have added a new conception to our knowledge of the type of nervous control of muscular movement. The idea that nervous impulses are conveyed through nerves of the sympathetic system into muscular fibres has attracted world-wide interest. His discovery has thus illuminated that field of physiology rescued from darkness by the

genius of Magendie at the beginning of the nineteenth century, added to the brilliant picture of the mechanism of the regulation of motion by nerves expounded by Claude Bernard and extended our view of reflex action elaborated with so much detail by the late President of the Royal Society of London, Sir Charles Sherrington. Not only have these contributions given to us a better explanation of muscular movement, but they have formed the basis of new means of treatment which have given a new life to many cripples who had never expected to walk again.

The President announced that Dr. Walter Burfitt himself had generously defrayed the cost of the prize for this year in addition to the £500 he had previously provided for the foundation of the "Walter Burfitt Prize."

THE FOLLOWING PAPER WAS READ:

"An Extension of the Conception of the Distribution Co-efficient," by Ian William Wark, D.Sc., Ph.D. (communicated by Professor C. E. Fawsitt, Ph.D.).

LECTURETTE:

Mr. T. C. Roughley gave a lecturette (illustrated by lantern slides) on "Sharks and Shark Products."

AUGUST 7, 1929.

The four hundred and eighty-seventh General Monthly Meeting was held at the Royal Society's Rooms, 5 Elizabeth Street, Sydney, at 8 p.m.

Professor L. A. Cotton, President, in the Chair.

Thirty members and two visitors were present.

The Minutes of the preceding meeting were read and confirmed.

The President spoke of the loss sustained through the death of Mr. William Poole, a past President, and asked

the meeting to endorse the following motion carried at the Council meeting on 31st July, 1929:—

> "That the Council of the Royal Society of New South Wales records its high appreciation of the valuable services rendered to the Society over thirty-eight years as President, member of the Council and member by the late William Poole, who died on 16th July, 1929. His untiring zeal for the welfare of the Society during his term of office was of great worth to the Council in the direction of the affairs of the Society. His genial spirit and warm-hearted comradeship endeared him personally to his colleagues and fellow members. His outstanding labours in the realm of education and in his profession of engineering has had a very valuable influence upon his generation."

This was done, those present standing in silence.

The President also announced the deaths of Messrs. George Balsille and Edward Elliott and Sir Baldwin Spencer as honorary member and Clarke Medallist.

A letter was read from Mrs. Poole expressing thanks for the Society's sympathy in her recent bereavement.

The certificate of one candidate for admission as an ordinary member was read for the second time.

The following gentleman was duly elected an ordinary member of the Society:—Allan Robert Callaghan.

The President announced that Mr. C. A. Sussmilch would deliver a Popular Science Lecture entitled "The Occurrence and Origin of Mineral Oil," on Thursday, 15th August, 1929, at 8 p.m.

The following donations were received:—183 parts, 6 volumes and 7 reports.

THE FOLLOWING PAPER WAS READ:

"The Development of the Inflorescence of Avena Sativa L." by A. R. Callaghan, D.Phil., B.Sc., B.Sc.Agric. (communicated by Professor R. D. Watt.).

The paper was taken as read.

Addresses on the scientific work of the 4th Pacific Science Congress held in Java, June, 1929, were given as under:—

(a) Organisation and Agriculture, Mr. E. C. Andrews.

(b) Anthropology, Professor A. R. Radcliffe-Brown.

(c) Physical Anthropology, Professor A. N. Burkitt.

(d) Biology, Professor E. J. Goddard.

(e) Oceanography, Mr. G. H. Halligan.

(f) Geology and Geography, Mr. C. A. Sussmilch.

SEPTEMBER 4th, 1929.

The four hundred and eighty-eighth General Monthly Meeting was held at the Royal Society's Rooms, 5 Elizabeth Street, Sydney, at 8 p.m.

Professor L. A. Cotton, President, in the Chair.

Twenty-three members were present.

The Minutes of the preceding meeting were read and confirmed.

The President announced the death of Dr. John Frederic Codrington, who was elected a member in 1876.

Letters were read from Lady Spencer and Mrs. Codrington expressing thanks for the Society's sympathy in their recent bereavements.

The certificate of one candidate for admission as an ordinary member was read for the first time.

The President announced that Dr. A. H. Martin would deliver a Popular Science Lecture on Thursday, 19th September, 1929, at 8 p.m., entitled "Psychology of the Individual and his Vocation."

The President announced that arrangements had been made for Dr. Yonge to give an address to members on the

subject of the scientific work of the Great Barrier Reef Expedition. The lecture had been held on Thursday, 29th August, 1929, and was largely attended.

The following donations were received:—7 volumes and 220 parts.

THE FOLLOWING PAPER WAS READ:

"The occurrence of a number of varieties of *Eucalyptus dives* as determined by chemical analysis of the Essential Oils," Part III., by A. R. Penfold, F.A.C.I., F.C.S., and F. R. Morrison, A.A.C.I., F.C.S.

LECTURETTE:

Mr. W. B. Gurney gave a lecturette (illustrated by lantern slides) on "The Control of Insect Pests by Parasites."

OCTOBER 2, 1929.

The four hundred and eighty-ninth General Monthly Meeting was held at the Royal Society's Rooms, 5 Elizabeth Street, Sydney, at 8 p.m.

Professor L. A. Cotton, President, in the Chair.

Fifteen members and three visitors were present.

The certificates of three candidates for admission as ordinary members were read; one for the second and two for the first time.

The President announced that Professor J. P. V. Madsen would deliver a Popular Science Lecture, entitled "Production of Wireless Waves and their Method of Propagation," on Thursday, 17th October, 1929, at 8 p.m., in the lecture room of the electrical engineering department, University of Sydney.

A letter was read from Mrs. Elliott expressing thanks for the Society's sympathy in her recent bereavement.

The following donations were received:—189 parts, 7 volumes, and 3 reports.

THE FOLLOWING PAPERS WERE READ:

1. "The Testing of Lead Azide Detonators," by J. A. Cresswick, A.A.C.I., F.C.S., and S. W. E. Parsons, A.A.C.I., A.S.T.C.
2. "The Action of Acids on Diazo-aminobenzene," by Professor J. C. Earl, D.Sc., Ph.D.

LECTURETTE:

Mr. R. W. Challinor gave a lecturette on "Some Useful Applications of Acetylene."

NOVEMBER 6, 1929.

The four hundred and ninetieth General Monthly Meeting of the Society was held at the Royal Society's Rooms, 5 Elizabeth Street, Sydney, at 8 p.m.

Professor L. A. Cotton, President, in the Chair.

Twenty-two members and one visitor were present.

The Minutes of the preceding meeting were read and confirmed.

The certificates of five candidates for admission as ordinary members were read; three for the second and two for the first time.

The following gentlemen were duly elected ordinary members of the Society:—Fidel George Baur, Francis Lions, and Alexander James Matheson.

A letter from the Council for Scientific and Industrial Research, asking for information re research connected with the Whaling Industry, was read, and members were asked to forward any information to the Hon. Secretary.

The following donations were received:—286 parts, 9 volumes, 8 reports and 1 calendar.

THE FOLLOWING PAPERS WERE READ:

1. "Note on the Leaf Oil from *Dacrydium Franklinii,*" Hooker, by A. R. Penfold, F.A.C.I., F.C.S., and J. L. Simonsen, D.Sc., F.I.C.

Remarks were made by Mr. R. T. Baker.

2. "The Essential Oils of *Melaleuca decora* (Salisbury) Druce, and M. *nodosa* var. *Tenuifolia* (de Candolle) from the Port Jackson District," Part 1, by A. R. Penfold, F.C.S., and F. R. Morrison, F.C.S.

Remarks were made by Messrs. E. Cheel and R. T. Baker.

LECTURETTE:

Mr. M. B. Welch, B.Sc., gave a lecturette (illustrated by specimens and lantern slides) on "Veneers and their Utilisation."

DECEMBER 4, 1929.

The four hundred and ninety-first General Monthly Meeting of the Society was held at the Royal Society's Rooms, 5 Elizabeth Street, Sydney, at 8 p.m.

Professor L. A. Cotton, President, in the Chair.

Twenty-six members and five visitors were present.

The Minutes of the preceding meeting were read and confirmed.

The certificates of two candidates for admission as ordinary members were read for the second time.

The following gentlemen were duly elected ordinary members of the Society:—Robert Ewen Jeffery and David Paver Mellor.

The following donations were received:—99 parts and 2 calendars.

THE FOLLOWING PAPERS WERE READ:

1. "Some Mechanical Properties of Australian grown *Pinus insignis,*" Part II., by M. B. Welch, B.Sc., A.I.C.

2. "Some Properties of Red Satinay, *Syncarpia Hillii*," by M. B. Welch, B.Sc., A.I.C.

3. "Some Interesting Geological Faults in the Vicinity of Branxton, N.S.W.," by G. D. Osborne, D.Sc., and H. G. Raggatt, B.Sc.

Remarks were made by Sir Edgeworth David.

4. "Notes on the occurrence of Quartzite containing Common Opal and Chalcedony at Tallong, N.S.W.," by L. A. Waterhouse, B.E., and Assist.-Professor W. R. Browne, D.Sc.

Remarks were made by Sir Edgeworth David.

5. "Studies on the Hydrolysis of Cellulose," Part I., by Miss J. Chalmers and Prof. J. C. Earl, D.Sc., Ph.D.

Remarks were made by Messrs. R. W. Challinor and A. R. Penfold.

6. "Some Trimethoxy-Quinoline Derivatives," by F. Lions, B.Sc., Ph.D.

7. "Researches on Indoles," Part I., 2-Methyl-5:6-dimethoxyindole, by F. Lions, B.Sc., Ph.D.

8. "Cyanogenetic Glucosides in Australian Plants," Part II., *Eremophila maculata*, by H. Finnemore, B.Sc., F.I.C.

GEOLOGICAL SECTION.

ABSTRACT OF PROCEEDINGS

OF THE

GEOLOGICAL SECTION.

Annual Meeting, April 26, 1929.

Assistant-Professor Browne was in the Chair, and nine members were present.

Mr. C. A. Sussmilch and Dr. G. D. Osborne were elected Chairman and Honorary Secretary respectively for the year.

EXHIBITS AND DISCUSSION:

1. By Dr. G. D. Osborne: (i) A series of specimens of ironstone containing plant remains; locality, Armidale; age, probably late-Tertiary. (ii) Ferruginous grit and conglomerate of Tertiary or Pleistocene age; locality, Armidale. (iii) Ironstone with fossil insect wing (?); locality, Armidale.

2. By Mr. W. Clark: Specimens of granite, pegmatite, greisen and schist from about 20 miles S.E. of Albury, between the Ovens and Mitta Mitta Rivers. These rocks are probably Ordovician in age, and equivalent to the Omeo Complex.

3. By Mr. M. Morrison: (i) Bismuth ore from Hermindale. (ii) Tantalite (?) from Pt. Darwin, with abnormal specific gravity of 7.8.

4. By Mr. H. F. Whitworth: (1) From Bellbird Colliery, iridescent coke produced from the dust on mine floor and walls during the course of a recent explosion.

(ii) Emery nodule, which occurred in basalt. (iii) Two specimens from Attunga, N.S.W., showing two stages in the development of magnesite from serpentine.

5. By Mr. T. Hodge Smith: Rare minerals recently acquired by the Australian Museum, as follows:—(i) Rubellan = altered biotite-leucite-basalt-tuff. (ii) Curite (Lead-Uranium-silicate) associated with torbernite and kasolite; locality, Belgian Congo. (iii) Gummite and Uranophane surrounding Uraninite; locality, North Carolina. (iv) Chalcostibnite, from Province of Morocco. (v) Altered basalt with much iddingsite; locality, Bagdad Hills, California, U.S.A.

6. By Dr. A. B. Walkom: (i) Two terminal shoots of (?) *Glossopteris*; the specimen showed terminal cones bearing sheaves of leaves; locality, Gloucester, N.S.W. (ii) Specimen from the Dirty Seam, Dudley, N.S.W., showing in association, a "scale-leaf" of *Glossopteris*, a large winged seed (*Samaropsis Pincombei*) and groups of so-called microsporangia of *Glossopteris*. (iii) A typical *Glossopteris* "scale-leaf."

7. By Dr. W. R. Browne: (i) Glassy dacite from the head of the Clarence River, showing perlitic cracking with associated columnar structure on a small scale. (ii) Schists and phyllites from Michelago, N.S.W.

All the above exhibits were widely discussed.

May 24, 1929.

Assistant-Professor Browne was in the Chair and five members were present.

The Honorary Secretary was instructed to write to the Rector of St. Ignatius', Riverview, expressing the regret of members at the death of Rev. Father Pigot, S.J.

EXHIBITS:

1. By Mr. M. Morrison: (i) Haematite with rhomboidal cleavage; locality, South Coast, N.S.W. (ii) Ilmenite from Central Australia. (iii) Large *Martiniopsis*, with unusual ribbed-markings; locality, Cessnock; (iv) Glendonite in calcareous concretion, from Glendon, N.S.W.
2. By Assist.-Professor Browne: A concretionary siliceous object of ellipsoidal shape and characteristic exterior; possibly Beekite; locality, unknown.
3. By Dr. G. D. Osborne: Common Opal from Bellinger River District.

All the exhibits were discussed by members.

June 28, 1929.

Mr. C. A. Sussmilch was in the Chair, and nine members and three visitors were present.

EXHIBITS:

1. By Assist.-Professor Browne: Villiaumite (Na fluoride) in nepheline syenite from Guinea. Sent by Professor Lacroix.
2. By Miss I. A. Brown: Suite of specimens, photographs and maps illustrating the volcanic islands of Krakatau and certain volcanic areas in Java. Miss Brown described many points of interest concerning these areas. The specimens exhibited were: (i) Basic inclusion in the boulders of the Kloet Lahars, Eastern Java. (ii) Pumice, Lang Island; from the 1883 eruption of Krakatau. (iii) Scoria from Anak Krakatau, a new island built up by the 1928-1929 eruption at Krakatau. (iv) Tridymite-hypersthene-andesite, from Rakata Island, Krakatau. (v) Scoria, hypersthene-andesite, Anak Krakatau. (vi) Obsidian from Lang Island, Krakatau. (vii) Typical andesite from the Kloet

Volcano, Java. (viii) Hornblende xenocryst in boulder of the Kloet Lahars, Eastern Java. (ix) Spherulitic Obsidian, Goenoeng, Central Java.

3. By Mr. H. G. Raggatt: (i) Highly fossiliferous Upper Marine calcareous shale, from a little south of Antiene. (ii) Erratic in Upper Marine Series with *Strophalosia* attached; locality, Loder, six miles south of Singleton. (iii) Fine white tuffs with *Glossopteris*; from the Greta Series, near Muswellbrook. (iv) Glendonite from the Crinoidal Shales, ½-mile east of St. Hilliers, Muswellbrook district. (v) Specimens from dyke cutting through coal measures at Muswellbrook. (vi) Basalt from Tertiary (?) plug near Grasstree. (vii) Photographs by Mr. Booker taken in St. Hilliers' Colliery, showing dyke-rock intrusive into coal and coke prisms due to same. Also photograph of what is probably thickest coal seam in the State (viz., 48 feet). Also photograph showing anticlinal structure in Whitburn Colliery, the thickness of the coal varying abruptly. Photograph showing minor faulting in same colliery. (viii) Specimens of clastic rock from St. Hillier's Colliery, the mode of occurrence is in doubt. (ix) Basalt with scoriaceous patches; the origin of the structure in this rock being unknown; locality, Liddell, N.S.W.

All these exhibits were widely discussed.

4. By Mr. H. F. Whitworth: (i) Galena and blende replacing crinoidal limestone, the crinoid stems being selectively replaced. (ii) Large crystals of rutile from 150 miles N.E. of Alice Springs.

5. By Mr. W. Poole: (i) Specimens of Miocene Limestones and also cemented sand-rock from near Pt. Fairy, Victoria, N.S.W. (ii) Photographs of Tower

Hill area, near Warnambool, Victoria. (iii) Graphs registered by barograph on successive days in Rockhampton.

6. By Dr. G. D. Osborne: On behalf of Rev. R. T. Wade, specimens of Hawkesbury sandstone with fragments of shale and nodules of iron pyrites; locality, Dee Why, N.S.W.

Mr. E. C. Andrews gave a short address upon the recent Science Congress held at Java, dealing with the general aspects of the Congress activities.

Mr. C. A. Sussmilch described in a comprehensive way, the proceedings of the Geology and Geography Sections at the Congress, discussing some of the chief results of the meeting.

Mr. Waterhouse drew the attention of members to the fact that some mention had been made of a proposed road through the Devil's Coach House at Jenolan Caves, and it was decided to obtain information about the matter and discuss it at a subsequent meeting.

July 26, 1929.

Mr. Sussmilch was in the Chair, and seven members and three visitors were present.

The following resolution, moved by Sir Edgeworth David, was carried in silence:—

> "That the members of the Geological Section of the Royal Society of New South Wales desire to record their deep regret at the death of their esteemed friend and beloved colleague, Mr. William Poole, and wish to extend to the bereaved relatives their heartfelt sympathy."

EXHIBITS:

1. By Dr. G. D. Osborne: Aragonite with fibrous radial structure from near the Cotter Dam, Federal Territory.

2. By Mr. T. Hodge Smith: (i) Black vitreous mineral from Zinc Corporation, Broken Hill, N.S.W.; the mineral is associated with calcite and galena. It is apparently a hydrous silicate of manganese and iron. (ii) Section of unique chiastolite from Bimbowrie, South Australia.

3. By Miss I. A. Brown: *Lepidocyclina* Limestone, from massive foraminiferal limestone horizon at base of the Miocene; locality, Tagogopoe Mts., west of Bandoeng, Java.

Mr. C. A. Sussmilch addressed the Section on the "Geology of Java," giving a comprehensive account of the stratigraphy, physiography, structural geology and vulcanology of the Island of Java. He also discussed the relations of Java with some of the other islands in the Netherland East Indies.

Some discussion by members followed the address.

August 30, 1929.

Mr. C. A. Sussmilch was in the Chair and eight members and two visitors were present.

A letter of thanks from the family of the late Mr. W. Poole was read.

Assistant-Professor W. R. Browne presented a paper entitled "Abyssal Injection and some of its Implications."

After referring to the prevalence of the "stromatolithic" type of intrusion in areas that had been subjected to great compression he described the characteristic features associated respectively with the two types of bathyliths, viz.: (a) the orogenic or synchronous batholith, and (b) the subsequent batholith. He referred to his experience with intrusive masses which to some extent showed features intermediate between the two types.

Dr. Browne dealt with the general aspects of the mechanics of intrusion of the various types, pointing out the relationships of the bathylites to geosynclinal areas.

Some palaeogeographical implications of the presence of large intrusive masses were then dealt with.

The paper was discussed by Sir Edgeworth David, Professor Cotton and Messrs. Andrews and Whitworth.

September 27, 1929.

Mr. C. A. Sussmilch was in the Chair, and nine members and five visitors were present.

EXHIBITS:

1. By Mr. L. L. Waterhouse: (i) Beach Sand from Bareke, British Solomon Islands; the sand contained olivine, magnetite, ilmenite, and augite; Professor Cotton suggested that the olivine and augite were derived from a friable basic tuff. (ii) Sand from beach on east side of King Island, containing ilmenite, magnetite, tinstone, monazite, augite, topaz, quartz, zircon and osmiridium.

2. By Assist.-Professor Browne, on behalf of Miss D. R. Taylor and Mr. C. T. Grout-Smith: A suite of specimens from the Lansdowne District, Middle North Coast, N.S.W.; the area is of extreme interest on account of the occurrence of plugs and flows of alkaline rocks, doubtlessly co-magmatic with the Tertiary masses of the Nandewar and Warrumbungle Mountains. The rocks comprised trachytes and pitchstones and other rocks of the alkaline rhyolite family. The exhibit excited much interest and was discussed in full.

3. By Mr. H. F. Whitworth: (1) Varve-rock (?) from Poolamacca, near Broken Hill. (ii) Rhodocrosite from Zinc Corporation, Broken Hill.

4. By Dr. G. D. Osborne: Photographs and lantern views of interesting structures in the Long Bay district.

Mr. H. F. Whitworth presented a paper upon "The Mineralogy and Origin of some Beach-Sand Concentrates of N.S.W."

He drew attention to the places where these concentrates are found and gave an account of his investigation upon their contents. In connection with the Sydney district beaches it was shown that the heavy mineral content was qualitatively much the same as that obtained from samples of crushed Hawkesbury sandstone. This suggests that the concentrates on the beaches occurring at no great distance to the north and south of Sydney, were derived originally from the disintegration of the Hawkesbury sandstone.

In the same way the concentrates on the North Coast beaches may have been derived from the Mesozoic Clarence Series.

The paper was based upon a great deal of extremely tedious and minute investigation. Professor Cotton pointed out the desirability of determining the radio-active content of the minerals with a view of ascertaining the absolute age of these minerals.

October 14, 1929.

Mr. Sussmilch was in the Chair, and twelve members and twenty-five visitors were present.

A hearty welcome was extended to Professor Douglas W. Johnson, of Columbia University, New York, and Mrs. Johnson, and also to Dr. Henderson, Director of the New Zealand Geological Survey.

Professor Johnson delivered a very instructive lantern lecture entitled "Studies in Shore-line Physiography."

He dealt with the shore-line features of the Atlantic Coast of North America and discussed in detail the problems connected with the determination of the chronology

of the strand-line in late geological time. A fine exposition was given of the criteria by which one could recognise emergence or submergence as having affected a coastline at a relatively recent date. The later physiographical history of the Atlantic Coast of the United States was fully discussed and comments were made upon Daly's researches into the latest movements of the strand line.

A vote of thanks was accorded the lecturer on the motion of Sir Edgeworth David and Mr. E. C. Andrews.

November 29, 1929.

Mr. C. A. Sussmilch was in the Chair, and ten members and nine visitors were present.

The Hon. Secretary reported that a half-day geological excursion was held to Maroubra and Long Bay on Saturday, October 26th.

EXHIBITS:

1. By Mr. H. F. Whitworth: Specimens of clay containing nodules and disseminated masses of vivianite, from New Zealand.
2. By Mr. E. J. Kenny: Nodule of barytes from White Cliffs, N.S.W.; this and similar nodules were supposed locally to be composed of a lead compound.
3. By Mr. F. W. Booker: Fossils from Belford, N.S.W., viz.: (i) *Wyndhamia dalwoodensis* sp. nov. (ii) *Branxtonia typica* sp. nov. (iii) *Wyndhamia valida* sp. nov. (iv) *Stutchburia costata.* Also *Productus Brachythaerus* and *Productus* sp. from Muswellbrook, N.S.W. (The types (i), (ii), and (iv) are described in Journ. Roy. Soc., N.S.W., lxiii, p. 24 et seq.)
4. By Dr. G. D. Osborne: A collection of Indian fossil plants sent to University of Sydney by Professor B. Sahni, of Lucknow University. (i) *Gangamopteris Kashmirensis* Seward; locality, near Srinagar, Kash-

mir. (ii) *Mesembrioxylon Partasarathyi*, from Vellum, west of Madras. (iii) *Glossopteris* sp.; locality, Apharwat, Kashmir district. (iv) *Noeggerathiopsis Hislopi*; locality, Apharwat. (v) *Glossopteris* sp., from Raniganj Coalfield, Behar district. (vi) *Vertebraria indica*, from Raniganj Coalfield. (vii) *Ptilophyllum* sp. and two detached pinnae of *Nilssonia* sp. (viii) *Gleichenites gleichenoides*; locality, near Bindrabum, in the Rajinahal Hills. (ix) *Nilssonia* sp. cf. *N. Morrisiana*; locality, Rajinahal Hills. (x) *Ptilophyllum acutifolium*, Morr.; locality, N.W. Rajinahal Hills.

Dr. A. B. Walkom addressed the Section on "The *Glossopteris* and *Thinnfeldia* Floras in South Africa and Australia."

He pointed out that the general succession in the South African Upper Palaeozoic is much the same as in Australia, except that on certain horizons there is an abundance of land animals which assist in inter-continental correlation. He then summarised the facts concerning the range of the *Glossopteris* and *Thinnfeldia* floras in Eastern Australia (particularly N.S.W.) stressing the importance of the time of appearance of a flora in any scheme of correlation. The general stratigraphy of the South African Upper Palaeozoic was then discussed and certain correlations made and comparisons instituted.

Dr. Walkom referred to the discussion on "Gondwana Land" that had taken place at the recent meeting of the British Association for the Advancement of Science in Africa, and explained that he had suggested a possible explanation of the peculiar associations and minglings of the *Glossopteris* and *Thinnfeldia* floras. This was that in addition to the dispersal of types from a northern centre there had been a migration northwards from the southern hemisphere of the *Thinnfeldia* flora, the result being a series of puzzling associations between different floras.

The address was discussed by Professor Cotton, Professor Browne and Messrs. Sussmilch, Kenny and Whitworth.

The Secretary was requested to obtain what information was available regarding the rumoured proposal to construct a road through the Devil's Coach House at Jenolan Caves.

Mr. Shearsby reported in reference to the reservation of an area at Hatton's Corner, near Yass, that the matter was still incomplete.

SECTION OF INDUSTRY.

ABSTRACT OF PROCEEDINGS

OF THE

SECTION OF INDUSTRY.

Officers—Chairman: A. D. Olle, F.C.S.

Honorary Secretary: H. V. Bettley-Cooke.

Reports re visits paid to Industrial Works during the year 1929:—

May 21st—Arnott's Biscuit Factory, Homebush.
June 18th—Hadfield's Steel Works, Alexandria.
July 16th—Newland's Bedstead Works, Surry Hills.
Aug. 20th—Lewis Berger's Paint Works, Rhodes.
Sept. 19th—Palmolive Soap Works, Balmain.
Oct. 15th—The Cream of Tartar Works, Camelia.
Nov. 19th—Peter's Ice Cream Works, Redfern.

SECTION OF PHYSICAL SCIENCE.

ABSTRACT OF PROCEEDINGS

OF THE SECTION OF

PHYSICAL SCIENCE.

Seven meetings were held during the year, the average attendance of members and visitors being 12. The election of officers for the year was held at the May meeting and resulted as follows:—

Chairman: Professor J. P. V. Madsen, D.Sc., B.E.
Honorary Secretary: J. Bannon, B.Sc.

Council: Associate Professor Bailey, M.A., D.Phil., F.Inst.P.; Associate Professor Wellish, M.A.; Assistant Professor Briggs, B.Sc., Ph.D., F.Inst.P.; Major E. H. Booth, M.C., B.Sc., F.Inst.P.; G. Godfrey, M.A., B.Sc.

April 17, 1929

Professor Wellish in the Chair.

Major E. H. Booth read a paper on "The Present Position of Seismic Geophysical Prospecting."

The speaker briefly outlined the principles involved in the Seismic method of Geophysical Prospecting, mentioning the apparent discrepancy between theory and practice in accounting for the refracted ray, referring to Jeffrey's work in this connection. He described the different types of detecting and recording apparatus in use at Gulgong by the Seismic Section of the Imperial Geophysical Experimental Survey, and showed that they were getting

consistent results as to depth and outline of underground strata—bedrock—on the deep lead which they are at present investigating. He pointed out that the nature of the bedrock appeared to be a hard clay state, in which the refracted wave travelled with a velocity of 12,800 feet per second; this last statement, however, being dependent on the accuracy of Jeffrey's work.

May 15, 1929.

Professor Wellish in the Chair.

Mr. W. Love opened a discussion on "Photographic photometry."

Photometric methods in the optical and X-ray region were described.

The method of measuring photographic density and the difficulties associated with same were considered, and it was shown that under certain conditions, the density of a spectrum line is measured by the height of the line registered by the microphotometer.

The relation

$D = f(it^p)$, where
D = density of line
i = intensity of radiation
t = time of exposure
p = constant

was treated from various aspects, and general methods of comparing relative intensities in the optical region were given.

In the X-ray region the above relation can be simplified considerably. Methods of comparing intensities in the X-ray region were described, and such a determination for the β group in the L spectrum of tungsten was described in particular.

June 19, 1929.

Professor Wellish in the Chair.

Dr. G. H. Briggs gave an account of Recent Theoretical Advances in Radio-activity.

R. W. Gurney and independently G. Gamow have suggested an explanation of the escape of alpha particles from radio-active substances based on the ideas of the New Wave Mechanics. The alpha particles are regarded as having an energy insufficient on classical mechanics to enable them to surmount the potential barrier surrounding the nucleus. However, on the wave mechanics an alpha particle has a finite probability of escaping through this barrier. Mathematically the problem is analogous to the reflection and transmission of a wave at a refracting barrier, the ratio of the transmitted to the incident intensity giving the transformation constant. Further the probability of escape increases rapidly with the energy of the alpha particle and on fitting certain available mathematical constants for one member of a transformation series, the well known Geiger Nuttal law is very well accounted for. An extension of the theory to the disruption of atomic nuclei by alpha particles gives results in good agreement with the experiments of the Cambridge School.

July 17, 1929.

Professor Madsen in the Chair.

Mr. W. G. Baker, B.E., B.Sc., read a paper on "A Method of Determining Mean Free Paths of Electrons in Gases."

The method depends on the production of positive ion sheaths over all electrodes in a tube containing gas at a low pressure. The main part of the voltage drops are concentrated in the sheaths and the body of the gas is prac-

tically field free. By taking volt-ampere characteristics the fraction of electrons deflected through a given angle at collisions can be determined, and hence the fraction suffering collisions.

September 18, 1929.

Professor Madsen in the Chair.

Professor V. A. Bailey read a paper on "A New Principle for the Measurement of Velocities of Electrons in Gases."

The method depends on the effect of a uniform magnetic field on the divergence of a stream of electrons which move in a gas under the influence of an electric field which acts in the same direction as the magnetic field.

The following theorem was established. In an apparatus of the usual type the magnetic field of intensity H affects the distribution ratio r as if the quantity Z/kc becomes $Z\sigma/kc$, where

$$\sigma = 1 + (HW/Z)^2$$

This theorem was established by means of experiments carried out with hydrogen, in which gas the velocity of electrons is known for a large range of values for the ratio Z/p. The experiments gave results which were in complete agreement with the theory.

Several detailed methods, based on this theorem, were then described, and were shown to read the following formulae for the velocity W:

$$W = Z/H \sqrt{(n-1)}$$
$$W = Z/H \sqrt{(1-1/n^2)}$$
$$W = Z/H \sqrt{(k-1)}.$$

The last formula is particularly applicable when negative ions are present. All these methods when applied to hydrogen were found to give results in good agreement

with those obtained in 1921 by means of Townsend's well known method.

p = the pressure of the gas.
Z = the electric intensity in volts per cm.
H = the magnetic intensity in e.m.u.
W = the velocity of drift of the electrons in the direction of Z.
k = the mean energy of an electron in terms of the mean energy of a molecule at 15°C.
C = the inner electrode distance.
n = an arbitrary factor of variation of p, Z or C.

October 16, 1929.

Professor Madsen in the Chair.

Professor Bailey read a paper on "The Adventures of Slow Electrons amongst Molecules of Ammonia."

After a description of the behaviour of electrons moving in a steady state, under the influence of an electric field, amongst molecules, the methods used for determining the facts were briefly outlined. The methods for determining $k + \alpha/p$ have already been described some time ago, and the method for determining W was given at the previous meeting. The application of these methods to the molecules of ammonia was described in some detail and the resulting values were used to determine the values of the mean free path L of an electron, the fraction λ of energy lost at a collision of an electron with a molecule, and the probability h of attachment of an electron at the collision. The most striking result was the increase of h from 0.4×10^{-5} to 50×10^{-5} as the velocity of agitation of the electron changed from 2.6×10^{7} to 9.8×10^{7}.

November 20, 1929.

Professor Madsen in the Chair.

Mr. W. G. Baker, B.E., B.Sc., read a paper on "Corrections to Measurements of Field Strengths with Loop Antennae."

The paper treats with the question of measurement of the electric field strength from wireless transmitting stations, and deals with refinements on the ordinary methods of measurement. The loop antenna is taken as equivalent to an electric transmission line with uniformly distributed resistance, inductance and self-capacity.

The loop resistance is usually measured by noting the effect of an added resistance. The effect of this is shown to depend on the place of insertion, and also on where the voltage is introduced.

Correction factors are derived, making it possible to reduce the results of different methods to a common and correct result. Most methods of field strength determination depend on determining the loop resistance with a voltage introduced in a different way from that of the field to be measured, so that errors up to 20% can readily be made if these corrections are neglected.

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